THE GLASS INDUSTRY

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GLASS MELTING

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PART I

The author presents here the story of glass melting from the standpoint of personal experience covering a period of several decades. During this period, glass melting has gone through an evolutionary process that has resulted in a much improved and controllable process. The tank furnace is the specific system here considered, although references will be made to other systems insofar as they present factors which have been incorporated or discarded for reasons which at the time seemed valid.

Whether the incorporated or discarded factors contributed to long range evolutionary progress were means of slowing up that progress or were responsible for retrogression are in many cases open to question. The correct answer to these questions is important, and should provide direction to the ultimate desired result.

The author disagrees with many solutions that have been accepted as cures for the ills of glass melting. He feels that some of them have not resulted in progress, but have actually blocked the road to further progress even though in cases there was definite improvement in some specific part of the whole process. This is not a mere personal opinion, but is shared by many of the best minds in the industry who have become increasingly aware that for many reasons the glass tank furnace has reached a point of diminishing returns economically without arriving at its objective which should be superior quality.

There is a disposition among scientists, inventors, engineers and operators to consider the laws of evolution as academic, or at the most as applicable mainly to plant and animal life. This is not true, but per contra is extremely practical, and applies in a striking degree to the progress of the machine age and particularly to glass melting. What the ultimate objective of plant and animal evolution is we do not know. It is the subject of many and changing theories. But the process of evolution is becoming clearer. Data covering millions of years are now available.

This process differs in no essential respect from the evolution of mechanism except in the time element. We can compress this process from one requiring millions of years to one involving a few years. There is another vital difference especially in the evolution of glass melting, viz., that the ultimate objective is known. Roughly stated and perhaps oversimplified, this objective is the transformation of certain substances usually of granular and crystalline form, homogeneously mixed into an amorphous state with maintenance of homogeneity. But the process by which this is accomplished should conform to the same evolutionary process that applies to all progress for success, and departure therefrom will spell defeat.

To understand these laws of evolution is vital for even a superficial study of this glass melting problem for it must furnish the background and yardstick for proper appraisal of proposed changes. The author recommends the study of a recent book entitled "Human Destiny" by Vicount de Noüys which is the best exposition to date of the evolutionary process. Viewed with such background, the history of glass melting presents a striking example of a "Comedy of Errors".

General Considerations

These considerations are divided into four parts. First: To develop the thesis that the premise or foundation or approach to the problem has been and still is erroneous. Second: The analysis of two main factors of the glass melting process (fuel application specifically with the factor of heat recovery). Third: The analysis of the glass transformation itself. Fourth: What can be done about it.

It is recognized that these chapters are closely interrelated and cooperative, and their presentation must

necessarily involve considerable cross-reference. However, it is felt that this somewhat arbitrary division will provide a better arrangement for clarity, especially for the executive who in the last analysis is the one whose interest and support is necessary if the present obstacle or bottleneck to any substantial progress is to be eliminated. It is equally recognized that many other factors are present and important to any complete consideration of this subject, but that their inclusion in this presentation would confuse rather than clarify this complicated subject.

Part I.

The author's theory is based on the thesis that the main error is that the foundation or approach to the subject is historical and traditional. Historically, the approach to the tank furnace was the Siemens Regenerative Furnace of 1856. It included a preheat system valid at the time, and necessary to effect the high temperature essential for efficient glass melting with the use of the low B.T.U. producer gas of that time. It consisted also of the glass containing structure or tank in which the confined molten glass was subject to a surface application of heat while its exterior was cooled by radiation to air at room temperature, or artificially cooled by air from blowers, or in extreme cases, by metallic water containing contact elements.

The containing element or tank was arranged so that batch was fed in one end and the finished glass taken out at the opposite or working end. This complete system was a revolutionary advance and comparable in importance with the Bessemer process of steel making. But it was not the preheating system nor the tank structure that was the important contribution to progress, but a fundamental functional one that substituted a continuous for an intermittent system of melting. Moreover, it conformed to an evolutionary law of progress that a continuous system in lieu of an intermittent one results in progress and the intermittent systems usually decline or disappear. This is shown in innumerable cases in many of the developments of the machine age.

There was a structural and a functional invention of importance. The knowledge of combustion and temperature, the refractories and other things were inferior to present-day knowledge and materials. Research and development were progressively applied to improve the original structure and function. All of which was in line with progress up to a certain point.

What the research men and designers did and still do not properly evaluate, is the fact that the product was not better but poorer than the product of the intermittent pot system which it largely replaced. The question of cost and quality have always conflicted, and even today the average quality of tank glass is not equal to the quality of pot glass.

Plate, optical and other glasses of top quality are still made to a considerable extent in pots. If we apply the laws of evolutionary progress to the tank furnace of today, we see certain things that are in line and others that are definitely not. In the author's theory, the approach to the problem is erroneous. It is a concept or premise based on structure rather than function. Improvements to the structure are important but not as important as improvements in function. The function of heat absorption should be radically altered. The function of transformation from batch to finished product likewise. At the same time, the product which is the primary purpose of the furnace has not been sufficiently improved.

The primary mistake in our approach is the acceptance of a certain structure, thereby directing our efforts to refinements of this structure rather than improving or even altering its functions. Once such a concept has been accepted (in this case for nearly a hundred years), it is obvious that the easy road to progress is to refine that structure rather than to change its functions. As a result, research and improvement did achieve better results to a certain extent. That certain features and functions are not the best and prevent the development from achieving the best ultimate result, brings out the conflict between a well-established, and perhaps a fairly satisfactory system and a new untried one in which risk, trial, and error are inevitable and present problems to be overcome.

The cold fact is that the pot system of glass melting not only produces better glass, but it is an open question whether it can not do it cheaper when all factors are equalized. Moreover, it is entirely possible and even probable that the pot system can retain the one important tank function, viz., continuous operation. Let it be understood that this is no attempt to present a modified pot system as a forward step as opposed to a tank process or perhaps something else. It is merely to illustrate the fact that other methods have their advantages and their faults.

The correct procedure (evolutionary wise) would be to eliminate faults of the one and incorporate the advantages of the other in some structure designed to carry on the proper functions of glass melting, and thus keep progress on a true evolutionary plane. This is the only course that can possibly produce the best ultimate result. The acceptance of any structure which has inherent basic functional faults obviously forbids such a course. Fortunately, as will be developed in Chapters 2 and 3, functions of both tank and pot melting structures are possible that will do this and at the same time decrease net cost of operation.

Part II. Combustion and Heat Absorption Functions

These functions are so closely related that reference to both is necessary. The emphasis, however, is placed on the combustion system leaving to Chapter 3 the task of detailing the heat absorption function. As previously stated, the Siemens structure used preheated air or gas and air as the basis of its combustion system. This was necessary in 1856.

The necessity for obtaining the desired temperature by this means no longer exists. The means (i.e., the Siemens structure) still exists, but the necessity doesn't. However, as one-half of the heat energy was discharged from the tank heat saving through preheat of air was apparently an economic gain. For this reason, the preheat was used and it was and still is considered an economic gain as well as a temperature producing advantage. Thus, there was fixed a basis or approach to the tank design problem. This has become historical and traditional and is the first erroneous conceptional error

which we will examine. This is a structural concept, and thus blocks any functional progress (evolutionary wise). With the advent of modern high B.T.U. fuels, this concept is no longer necessary from the temperature standpoint. Temperature was and is the necessity. It has no relation to any particular structure. It is purely functional. Whether preheated air or fuel or both, whether a regenerator or recuperator produces the preheat, or whether any preheating system is used at all is today immaterial.

Either natural gas and oil without preheat can melt down the ordinary furnace. If for any reason it is desirable to boost temperature for the short time an area requiring the maximum temperature, many other means are available in commercial use such as oxygen enrichment, electric heat, or limited preheat obtained from furnace radiation.

These are only to illustrate the fact that air preheat from present day regenerators or recuperators is not a temperature necessity. The other factors, cost or economic considerations remain as the sole basis for limiting tank development design by imposing this structural concept. Just how this limits the more important function of transformation or the glass making cycle will be developed in Chapter 3.

All of the above facts are well known to the technical expert, and to the great majority of executives or capitalists. What is not so well known or at least does not register with either, is the fact that a factual appraisal of the economic factor of saving by preheated air is pretty much a delusion. As the only excuse for this preheat worship is economic, it will be well to examine this from that standpoint. A superficial reaction might be something like this. Over half the heat at high temperature (often higher than tank temperature) is discharged at the ports and would be otherwise wasted. This saving by recovery is substantial perhaps on the order of 25% under maximum load.

What is overlooked is that the gain in dollar cost saving must take into consideration the total cost of the preheating system which with modern insulation and control instruments is high. The only valid comparison would be the cost of the added fuel to replace the preheat less the net cost of the preheat. This in most cases, reduces the economic saving figure to a low point. In one case of a very good commercial tank operated to capacity, this figure was only 4%. Nor is this the important point. Inasmuch as the preheat system is only valid on economic grounds as temperature necessity has disappeared, the real problem both from the standpoint of the engineer, the owner or controlling heads is whether some other use might not be made of the heat leaving the tank that would have a higher economic value.

In the following chapter, I hope to show that this is possible and practicable. But more important is the fact that the retention of the present regenerative system of preheat handicaps the operation of glass making proper as it compels the designer to produce a structure for saving heat, and handicaps him in many ways in designing a tank for glass melting which is its primary purpose, and prevents the production of the best quality of product.

Over twenty-five years ago, I had a rather unique experience which probably had considerable to do in forming my opinion on this subject. A large successful glass plant equipped with many tanks was laid out with a rather short distance between tank centers. They enlarged tank width thus handicapping checker width and volume. As a result, the gases entered the stack at approximately 1500° F. The plant required considerable steam for power and other purposes, and a steam plant was installed to use the flue gases for generating steam. It was rather an elaborate affair and my first impression was that as an economic unit it would show a loss. When we collected the data of all costs, installation and operation we were surprised at the figure of nearly 50% saving on the investment.

The regenerator saving in preheat was probably less than 10% on an equal comparison. From the evolutionary standpoint, the regenerative system is obviously wrong as it is intermittent. This and many difficulties due to reversal are known and many others yet unknown. This has been recognized by engineers, and the recuperator or continuous system has been used and still is to a certain extent.

The pros and cons of the regenerator vs. the recuperator are not pertinent to this presentation. Suffice to say that evolutionary-wise, the recuperator with its continuous fuel application to the tank is correct except for economic reasons. But at best it is an air preheat system and outmoded, and is no more valid as a premise or approach to tank design than the regenerator. Both should be eliminated.

Part III. Melting or Transformation Function

This chapter is concerned with the actual cycle of the transformation of the batch into glass. Whatever may be the merits of some system of fuel combustion, waste heat saving, etc., the one which best effects this transformation is of main importance. Certainly, cost enters into the picture and a change in some portion of the process may be definitely better but its cost too high. In this case, we would like the best but can not afford to pay for it, so many choose an inferior but less expensive one. This is a compromise and therefore not progress (evolutionary-wise) but necessary for the immediate attainment of profit. This is a perfectly valid reason. What is not valid is the approach from this point onward.

The practical approach urges us to improve the accepted but inferior means. The evolutionary approach is to accept the superior means and develop a lower cost. These two courses confront us in nearly every progressive development, but in this tank problem especially, the choice of an inferior means at lower cost seems to be too much in evidence. Fortunately in this glass melting process, both lowered cost and superior function may be evolved in the same direction. The proper functioning of each stage in the melting process will result in better glass, and its net cost (including all items) is less. The question at once arises why a more expensive inferior process and structure has reached its present established position. The answer is that development by choosing the inferior solution is the easier course, although it ultimately reaches a stalemate. This tank progress has its counterpart in nature, and ultimately produced the "Dinosaur", that monstrosity of animal life which disappeared.

The modern tank furnace is somewhat analogous and will disappear ultimately through displacement by developments which follow the true course of evolutionary progress.

Analysis of Specific Functions and Structures. Glass melting is a complicated process and consists of many stages or steps only a few of which we will include in this chapter. These steps follow one another in a certain cycle regardless of any functional likeness or difference. Similarly, the best structure functionally and economically should be chosen for each stage regardless of the preceding or succeeding stage. Stages are often lumped together and their functions and structures embodied in one. This is perhaps the main reason why the modern standard tank is inferior functionally, and fails to produce the best quality of product.

For the sake of clarity and admittedly over-simplified, we will consider glass melting in six stages: Stage 1. Batch consisting of several materials usually granular and crystalline are mixed to effect homogeneity. Stage 2. Transfer of batch from mixing structure to heat absorption unit while maintaining this homogeneity. Stage 3. Absorption of heat from room temperature to some point below which the batch is changed in physical characteristics. Stage 4. Pastifying: Temperature melts the lower melting point ingredients, its liquid wets more refractory ingredients, certain chemical reactions by diffusion commence and some gases are expelled. Stage 5. Melting proper or reduction of all batch materials to a liquid, completion of chemical reactions, expulsion of gases of formation and larger bubbles. Stage 6. Clearing or refining. Attainment of maximum temperature and minimum viscosity, elimination of fine seed and completion of combination by diffusion.

For best results functionally, Stage 1 demands thorough agitation; Stage 2 demands no particle movement; Stage 3 demands heat absorption mainly by convection; Stage 4 demands violent agitation or mixing and heat absorption by convection, conduction and radiation; Stage 5 demands fluid heat absorption convection, radiation and, to a lesser degree, stirring or mixing. This agitation may be less violent, especially if Stage 4 is performed with homogeneity maintained. Stage 4 demands heat absorption mainly by radiation and fluid convection and is desirable for maintenance of temperature uniformity, laterally and vertically.

Stage 1 is a cold process while stage 4 is a heat absorption process but both require agitation and mixing. Stage 2 likewise is a cold process, and Stage 3 is a heat absorption process but both are best effected by an absence of inter-particle movement or mixing. Stage 5 and 6 are heat absorption processes, and stirring or mixing is not necessary for maintenance of homogeneity so much as for efficient heat absorption and maintenance of uniform temperature, provided that homogeneity has been maintained during the previous four stages.

It is obvious that as each stage requires a different functional operation, that the best structural means for each would normally be different. Stage 1 is pretty satisfactory in modern practice and needs no elaboration. Stage 2 is not as satisfactory as particle movement should be eliminated, otherwise Stage 2 will cause the homogeneity achieved in Stage 1 to deteriorate. Careful design and operation of conveying and tank feeding means have greatly reduced deterioration of the homogeneity achieved in Stage 1, but have not eliminated it.

Briquetting which is an intermediate stage between Stages 1 and 2 is here considered as a part of Stage 1 for simplicity of presentation. This is definitely the best system for the operation of Stage 2 and practically necessary for effecting Stage 3 efficiently.

Briquetting has two main advantages: First, it forms solidified portions of batch which effectively prevents unmixing during transfer from mixing unit to heat absorption unit and thereby simplifies and reduces the cost of the conveying means and renders its operation less sensitive. Second, by the compacting of the loose batch the co-efficient of heat conduction is increased, and thus permits the operation of Stage 4 cheaply and efficiently and the employment of waste heat from the furnace even without the elimination of the preheat if for any reason the preheat system should be deemed desirable.

There are other advantages from briquetting, absence of factory and furnace dust, etc. which are minor advantages from the glass melting standpoint but which have small net economic advantages.

I was assigned to study the briquetting problem and my report was to the effect that the elimination of factory and batch dust had some advantage, but from the economic standpoint these advantages were too small to warrant its use. However, as I shall later show, its use to effect the preheating of batch by waste heat is practical and would reduce the total fuel required for melting by at least 30%.

We might digress at this point to say that the advantages of briquetting was considered important enough from the glass melting standpoint that it was tried on a commercial scale in Russia, as it permitted practical performance of Stage 3 as an independent or separate operation.

The economic phase was neglected and preheating of briquettes in a line kiln type of structure was done though without the advantage of waste heat. Little reliable information is available except that it reduced the size and fuel cost of the melting tank, but used some primary fuel which would decrease its economic gain over waste heat means. Unfortunately, the iron curtain forbids much chance of obtaining further information. There is a Russian patent issued to the inventor showing a sketch of his structure and a description disclosing the purpose of his invention.

It is chiefly interesting in showing recognition of one item along the route of progress necessary to put tank design on a progressive evolutionary trend.

Stage 3 is important as it could well be a starting point toward real progress in melting glass. It not only has been tried out on a commercial scale, but its incorporation into the tank melting cycle outside of tank proper is not a difficult problem in engineering. It is a substantial economic gain as approximately one-third of the total heat required for finished glass is absorbed by the batch before its lowest melting ingredient has changed from a solid to a liquid form.

Stage 4 is important as a problem, the solution of which may constitute roughly another one-third of the total glass melting load. Like Stage 3 it could be effected as a separate operation or combined with Stage 3 as a single operation outside of the melting tank proper, and

thus reduce to one-third the glass load and consequently the size and fuel input of the tank proper.

Temperatures needed would be well below the temperature of the gases leaving the tank. Both these Stages 3 and 4 and in several cases, 3, 4 and 5 have been successfully and individually performed experimentally on commercial sized units. Also there are in commercial use on a large scale, glass melting units that perform Stages 3, 4 and 5, in one unit and Stage 6 in another unit. This operation was not developed for economic reasons, but solely for the production of a higher quality of glass than was possible when the standard tank which performs Stages 3, 4, 5 and 6 in one unit was employed as is now done almost universally.

More Specific Functional Details of Standard Tank Practice. Up to this point, we have divided glass melting arbitrarily into stages. We have outlined the sequence of these stages, and in a general manner in what these stages consist. The functional aspect of these stages requires more specific detail, why separation is desirable from both the functional and structural standpoint. After preliminary mixing, it is obvious that a homogeneous state should be maintained at every stage.

After heat is first applied, each stage should progressively increase its heat content up to maximum. Obviously homogeneity should be maintained throughout all states. Otherwise, additional time and fuel would be required to undo any backward step toward inhomogeneity. In addition to maintenance of homogeneity, the best time factor should be ascertained for each stage.

We have considerable data from observation of commercial operations, but the time required for each stage is not accurately well known or the effect of different time elements on ultimate quality. Some additional research data is required. We know that in small quantity, glass can be made from batch in eleven minutes. We know that in pots, plate glass can be made in approximately 8 hours in a quantity of over a ton. But it usually requires 22 hours to do this because of economic reasons. Also for economic reasons, tank glass requires from 20 to 72 hours to complete this transformation. In all instances where large tonnage is sought, the increased time is necessary partly because the transformation process is not progressively continuous. In the case of pot melting, the fill is not sufficient to eventuate in a filled pot of finished glass.

The volume shrinkage of batch and the addition of substantial quantities of fresh batch to the original fill after it has completed several stages is necessary to obtain a full pot of finished glass. Even so it is usually the practice to allow the pot to boil over resulting in a loss of glass of substantial amount (as high as 25% in some cases). Another reason for this waste is the necessity for avoiding damage to the pot with upper portion exposed to the hot temperature of fining or finishing. In the tank this "boiling over" is eliminated and the upper portion of flux blocks is heated on only one side. Otherwise, the retrograde step in the transformation process is the same differing only in degree and due to other causes.

This brings up the question of tank convection currents which is receiving considerable attention at present. Although convection currents have been known to exist from the beginning of tank operation, the knowledge of their characteristics, causes and importance is comparatively recent. We are just beginning to learn something about them, mainly that they have bad as well as good effects. This apparently simple phenomenon has become a very complicated subject. These currents are sensitive, hard to control and are present wherever a continued glass body is heated on one area and cooled on another.

In pots, the heating and cooling are matters of relative small degree whereas in the tank this difference is much greater. Again, these tank currents vary in response to changes such as differences in pull, composition, outside atmospheric conditions, and even to conditions caused by regenerative reversal. Tank proportion, presence or absence of floater, bridgewalls, etc. affect these currents widely. In pot melting, they are more controllable for another reason; viz., the batch in the pot becomes the finished mass, (particularly in plate glass manufacture) as a single integral unit. Per contra, the product of the tank may have been filled into the tank a matter of hours or days before the finished glass is withdrawn. Not infrequently one finds batch or cullet filled into a tank at the beginning of a campaign still remaining at the close of the campaign of many months.

The most striking example within my experience was the case of a tank that had been filled with cullet while cold. At the end of an eight-month campaign, a large mass of fused cullet weighing several hundred pounds from the original fill, survived the draining of the tank and was located in the middle of the tank laterally and not six feet from the doghouse forwardly. Another example was the case of a tank running the first half of a campaign on amber glass. Then flint batch of a somewhat lower melting point was added without interrupting the firing. In a matter of hours (not days), flint glass of bottle quality issued from the feeders, was packed, and this continued for the remaining one-half of the campaign.

I was fortunate to be present when they had quarried out about one-half (lengthwise) of the cooled glass. The lateral section at that point showed a maximum depth of 9 inches for the flint glass in the center of the tank sloping to approximately 1" at the blocks. Below was approximately 3 feet of amber glass apparently unchanged. This would explain the rapid change from amber to flint, but it left the question unanswered as to what had become of the convection currents. This kind of experience has had its effect in making me a heretic in the present worship of the benefits of convection currents.

This present-day worship of convection currents, as well as the worship of preheat regenerators, seem to the author to be about as superstitious and traditional as the ancient worship of Baal and similar graven images. But the variableness, unpredictability and lack of control, while serious functional factors, are not the worst characteristics of these currents. No doubt, certain convection currents particularly the lateral ones are useful, even necessary to present portions of the molten glass for heat absorption, and for assisting in maintaining the molten glass in fairly uniform temperature vertically. However, in standard tank melting practice, there are longitudinal convection currents sometimes of considerable extent. These tend to continually transfer portions of less finished glass to areas of further refined glass and

also glass from the refining end through the throat back into the melting compartment. Obviously, this is a retrograde stage in glass transformation.

It is equally obvious that a larger refining area, and a longer time are required than would be otherwise. In the case of pot melting, eight hours easily completes transformation when only the original fill is finished. As fresh batch is added, this time is extended to twenty-two hours commercially with added fuel proportionally greater than the added tonnage of glass. This is similar to the interchange through convection currents in tanks between finished glass and less finished glass. We are now able to trace convection currents from the feeder back through the throat, into the melting end until they reach that conglomerate mass of cold batch, pastified glass and melted liquid glass at the doghouse end of the tank.

Inasmuch as tank convection currents are an inherent characteristic, it is obvious we can not eliminate them entirely. As they may be roughly divided into lateral (beneficial) and longitudinal (detrimental) species, the obvious premise or approach to a proper tank furnace would be such that these lateral currents would be aided and longitudinal currents curbed. This means the elimination of several venerated portions of the modern tank. The bridgewall and its bottom or submarine throat must go. Personally, I have not found in theory or practice any use for them. They seem admirably adapted for the purpose of breaking up useful lateral convection currents and creating harmful longitudinal ones.

It is argued that it is a sort of skimmer and prevents unmelted batch from travelling into the working end, a sort of insurance policy against the tank getting out of hand. This is a fallacy known to every practical furnace operator. Designers recognized this and there was a period when glass was flowed over shallow planing tables instead of through bridgewall throats. Planing tables have their own difficulties, but if an owner insisted on some useless and harmful obstruction, I would prefer the planing table to the bridgewall and throat. Convection currents are caused by the improper operation of Stage 4 (pastifying) which is conventionally done in the melting tank where Stages 3 (initial heating of cold batch), 4 (pastifying) and 5 (melting proper) are all jumbled together. Superficially this indiscriminate jumbling might appear justified as a simplification. Why 3 separate operations when one will do? Why employ three separate and dissimilar means when a single means will do? The answer is that we have three different (functionally) operations which for efficiency alone separate means are desirable.

It is somewhat like the combination tool where a screwdriver, saw and hammer are ingeniously combined so that one can perform three different (functionally) operations with one tool. It can perform all these operations but the carpenter uses three separate tools only able to perform one operation each, but which can do it better than any one of the members of the combination tool.

This combination of glass melting stages causes inhomogeneity and glass currents of different composition and temperature begin their erratic travel laterally, as well as to and from the working area, etc. These currents are of substantial cross-section and once formed do not again easily unite or coalesce as this requires more violent agitation, penetration and mixing than is available within the tank. None of these required functions are characteristic of convection currents and this is so well known that any elaboration should be unnecessary. But this is again a case where this most obvious error seems to be ignored. Fluid mixing agitation requires penetration. Penetration requires high velocity and a broad angle of impact and low viscosity of the mediums, in this case fluid glass. These currents have none of these requisites in any substantial amount, yet we hear of the mixing due to convection currents as if it was a substantial factor. One does not need to be a technical expert to realize the absurdity of this. If one is a trout fisherman, he has doubtless seen a clear stream and a muddy one join.

The viscosity of medium (water) may be 1/10 or less, the angle of impact 90 degrees, and the velocity 600 times that of glass convection currents, yet, there is little mixing and the two currents flow together, not for a few feet but for miles, keeping a clear demarcation between muddy and clear currents. There is a small amount of coalescence between adjacent glass convection currents by diffusion. This is a molecular process, and quantatively negligible. It would require years not hours, to mix or stabilize adjacent streams of glass convection currents of substantial section by diffusion only.

Referring back to Stage 4 (pastifying), it would appear that this stage as accomplished in the melting end causes the worst case of inhomogenizing. This is aggravated by dumping cold batch, and including Stages 3 and 5 as a combined operation.

Rivulets and pools of low melting temperature alkalies segregate and agitation is mainly the ebullition of large bubbles or blobs of gas which is not an efficient mixing means. The wetting of the more refractory elements by the thin fluid alkalies is also inefficient. This particular stage is similar to the wetting of the sand and aggregate in concrete and would be done best by the same type of apparatus as Stage 1 or particle mixing. Owing to the high temperatures employed, this type of apparatus is not practical. It could be done efficiently by some form of revolving refractory lined drum which maintains the homogeneity of concrete mix and used in cement manufacture. As a separate operation waste heat from melting tank could be used for this instead of preheating combustion materials (fuel and air). This air preheat use of waste gas may be of some small economic value but it has no useful function for glass melting proper. Prior to pastifying (Stage 4), batch in briquette form could also be efficiently heated as a separate operation using still another efficient type of apparatus and using the tail heat discharged from the pastifying apparatus. This series of separate operations greatly assists the next following stage.

The tank operation proper (melting and refining) is thus reduced to approximately one-third as now performed and with a corresponding reduction in the size and cost of the expensive tank and preheat structure. Lateral convection currents are thus possible during the entire travel of the glass from introduction to working end. Now if we eliminate the bridgewall and regenerators, other improvements in both function and structure

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THE GLASS DIVISION MEETS AT BEDFORD SPRINGS

The twentieth Autumn Meeting of the Glass Division, American Ceramic Society, was held at Bedford Springs, among the Alleghenies of southern Pennsylvania. Charlie Pearce, General Secretary of the Society, took charge of the registration of 176—somewhat more than ten times the number assembled informally at Cove Point, Md., 1929. A few of those oldsters were present, but a cheering circumstance was that young men made up most of the gathering, furnished half the papers and spoke up prominently in the discussions.

Howard R. Lillie, Corning Glass Works, presided as Chairman, and also presented a paper which seemed to have emerged from the laboratory of the "Cascade Glass Co." In this pretentious treatise, a bold effort to measure the torque necessary to sever the silicon-oxygen bond was described in such a painstakingly scientific manner that many careful notes were scribbled. Note-taking ceased when a formidable integration formula, by the simple device of throwing out a few inconsequential terms and "constants," was reduced to the simple expression: Nu/ts. Smiles gave way to chuckles when the result, something like $(1.437615 \neq 0.8) \times 10^{42}$, was announced. Careful work, said the disclosure, might get results with a probable error of 50 per cent, but the actual error might reach 100 per cent. The audience was had. As a satire on some ultra-modern approaches to the behavior of glass by way of fine-structure hypotheses, the paper was a distinct contribution to fanciful literature. Acknowledgments were made to Rube Goldberg for one piece of apparatus, pictured as permitting a silicon-oxygen network, unusually random, to flow through a hopper, timed by an alarm clock.

Frank W. Preston, Preston Laboratories, Butler, Pa., practiced pedagogy in the use of Poisson Functions in the glass industry. The name means nothing lethal, just "fish." This part was played by several professors, chosen because the act required no brains. They dropped 100 marbles into 100 tubes passing in a sort of merry-go-round beneath the edge of a circular tray. McCormick and Ghering then did the heavy tallying of tube contents, and it was revealed that about as many tubes were empty as contained one marble each, while decreasing numbers of tubes held two, three, up to five marbles. The magic of the math involved resides in "e" (2.718..) of Napierian fame. That is, if 100 stones are found in 100 bottles, 100 divided by 2.718, or 36, bottles will probably be stone-free.

In the paper by Stig Lindroth and F. V. Tooley, University of Illinois, presented by Dr. Tooley, some quenched meltings of lime-alumina mixtures were described, in which glassy material was discovered. Skeptical discussion suggested the possibility of isotropic crystals which could be mistaken for glass. Non-vocal, old-fashioned listeners might have wanted to see some actual fibers drawn from the melts.

C. D. Spencer, of General Electric, back on our platform after a decade or two, showed how glass tubing for lamp bulbs may be run through a quick-bending apparatus to test it for breaking tendency. The invisible flaws are thus discovered, if not seen, before assemblies come apart. The slides were good, but a demonstration of the actual apparatus would have been more fun.

A rugged argument was offered by S. D. Stookey, Corning Glass Works, for the presence of an oxide of a noble metal in glass, previous to striking the color. As a general principle, it was stated that metals dissolve only in metals. Moreover, he suggested, gold ruby is best produced when a reducing agent such as arsenic (meaning As_2O_3: see Holscher and Helpers' Handy Hyalology) is present. Perhaps the fact that no oxide of gold or silver exists by itself above 300°C. has nothing to do with the question of its existence in glass.

After the dinner on Friday evening, W. Foss Curtis, Fostoria Glass Co., gave an extremely interesting talk on European Hand Glass Processes. Having visited England and a half-dozen countries on the Continent, and having observed at first-hand the operations in a large number of small factories, Foss was well prepared to give an excellent recital. The impressions that he passed on were particularly concerned with the cordiality and open-handed hospitality of his hosts and the high esteem in which Americans are held. The methods, he reported, were antique, but the workmanship was genuinely good. Nevertheless, the Europeans are anxious to install mechanical processes.

Aaron Lyle, Hartford-Empire Co., trustee of the Division, was then introduced, to present the awards established by the Preston Laboratories in memory of young technologists who lost their lives in the late war.

Dr. H. R. Swift, Libbey-Owens-Ford Glass Co., won the Frank Forrest Award for his papers on crystal growth in glasses. Dr. Kuan-Han Sun, Westinghouse Electric Co., won the S. B. Meyer, Jr. Award for his papers on densities and other properties of glasses.

In the Saturday morning session, Alexander Silverman spoke on the Glass Research Foundation. Later in the day, at the business meeting, a committee was provided to study the project.

H. K. Richardson, Westinghouse Electric Corp. (Bloomfield), told of the hundreds of different burners used in the lamp-working of glass for lamps and electronic tubes. His talk dealt with burners having gas orifices as small as 0.02-inch, whereas many of his listeners operate with gas ports several square feet in area. The little fellows produce some terrific temperatures, necessary for the speed and precision of lamp-and-tube assembly.

Oscar H. Grauer described an apparatus and a technique for determining liquidus temperatures of glasses, designed by himself and Edgar H. Hamilton, Bureau of Standards. The long tray previously used has been replaced by a platinum boat with dimples, closely spaced, in which small pellets of glass are nested in a furnace wherein a temperature gradient exists. Quick cooling, close estimation of temperatures and absence of confusing flow or travel of liquid glass are the advantages claimed.

New glasses for stopping X-rays were described by J. J. Rothermel, University of Pittsburgh, collaborator with Sun and Silverman. The best one was a lead-tung-

sten phosphate glass, capable of discouraging X-rays about four-tenths as well as metallic lead of the same thickness would do. Another good feature was the relative freedom from color and discoloration. Such glass might come in handy for stopping other emanations and to protect those who work with radio-active isotopes.

The business meeting cleared up some matters relative to a new provision in the Rules for a Research Committee, and routine committee reports were heard. Prof. F. V. Tooley occupied the Secretary's desk for the first time. C. H. Hahner, Bureau of Standards, incoming Chairman, acquired practice at conducting meetings. F. L. Bishop, American Window Glass Co., deserves great credit for planning the program.

On the whole, the papers are becoming talks and reports, as they should be, and as the recent revision of Rules insists. Some reading still goes on, and some slides are shown that conceal their information. The one accompanying Lillie's Hoax was a dreadful warning. A few pronunciations could be brought into line with good usage. A composite sentence might be built from what was heard, like this: "Reesearch, using the new apparattus, obtained new datta on abzorption."

John W. Whittemore, President of the Society, made gracious remarks about our Division, as did Charlie Pearce. Their praise only reenforced the proper pride of the Division in its size, enthusiasm, activity and friendly cohesion. The young technologists are flocking in, and the old ones stay.

It was pleasant to have a message of greeting from our colleague overseas, Professor W. E. S. Turner, who was with us last year.

Golf, managed by Bob Curts, who had wangled a fine lot of prizes donated by a number of companies, was a somewhat soggy affair. The course has a beautiful setting. It also has a number of brawling brooks that claimed a hatful of balls. Three-figure scores were common.

Brief summaries of some of the papers presented before the Glass Division follow:

X-Ray Absorbing Phosphate Glasses: PbO-WO_3-P_2O_5 System. *By J. J. Rothermel, Kuan-Han Sun and Alexander Silverman, University of Pittsburgh, Pittsburgh, Pa.*

Recent developments in nuclear science and technology have caused a demand for more efficient screens for the protection of personnel against physiologically harmful radiations emitted during nuclear reactions. While these radiations are of a number of types each one requiring separate consideration, it was the purpose of this study to investigate more efficient transparent barriers for the absorption of x-rays and γ-radiation. Due to the fact that lead is an efficient absorber of x-rays and γ-radiations and that lead monoxide and phosphorus pentoxide form clear (up to 75% by weight of PbO) and colorless glasses, the lead phosphate system was chosen for this investigation. As lead phosphate glasses possess low resistance to atmospheric attack, a preliminary investigation was made to increase durability by the addition of other metallic oxides, keeping in mind that such an addition should not impair the absorption. As WO_3 gave promising results, the PbO-WO_3-P_2O_5 system was given special consideration.

After a preliminary series of melts, twenty-eight different glasses within the clear glass forming region of the ternary system PbO-WO_3-P_2O_5 were prepared by laboratory procedures. In addition to the glasses prepared in the ternary system, a study was also made of the possibility of producing a glass with increased chemical durability and increased resistance to devitrification.

The following physical properties were measured on these glasses: density, color, spectral transmission, refractive index and x-ray absorption. Equations were developed from which specific volumes and lead equivalents may be calculated from composition. All of the glasses prepared in the system PbO-WO_3-P_2O_5 were, to varying degrees, attacked by moisture and showed devitrification tendencies, but investigation indicated that by the addition of small amounts of TiO_2 and CdO, practical glasses may be prepared. The composition of two of these glasses is given in Table I.

TABLE I.

	Glass Number 260		Glass Number 266	
Component	cationic %	weight %	cationic %	weight %
PbO	44.0	60.0	42.0	58.6
WO_3	15.0	21.3	15.0	21.7
TiO_2	2.0	1.0	5.0	2.5
CdO	2.0	1.6	1.0	0.8
P_2O_5	37.0	16.1	37.0	16.4

The outstanding properties of these lead-tungsten-phosphate glasses are: a) their superior lead equivalent over present-day commercial x-ray absorbing glasses; b) their extremely high density and refractive index (their high index of refraction and low dispersion make them useful as optical glasses); and c) their color stability under intense γ-radiation (this property is especially noteworthy because one of the chief objections to x-ray absorbing glasses is their darkening on exposure to high energy radiation).

A Brittleness Testing Device for Small Diameter Glass Tubing. *By C. D. Spencer, General Electric Lamp Development Laboratory, Cleveland, Ohio.*

Production speeds of the automatic machines used for the manufacture of glass tubing have been steadily increasing. As the drawing, cutting and gauging of such glass tubing requires mechanical contacts between the glass surfaces and metal surfaces, these increased production speeds have increased the violence of the glass-metal contacts with the result that glass surface damage has become greater. This increased glass surface damage is the primary factor responsible for complaints concerning low tensile strength and "brittleness" of glass tubing used in lamp and radio tube manufacture. (The term "brittleness" is used here in the same manner that the factory man uses it, i.e., glass tubing that fractures more readily than normal glass tubing.)

Unfortunately the visible scratches or abrasion marks have little or no effect on the tensile strength of commercial tubing. In order to act as a typical "stress raiser," a surface flaw must have a sharp entering edge and surface marks or abrasion usually lack this necessary element. Many of the glass-metal contacts result in the "stress raiser" type of flaw and usually are invisible to the unaided eye under ordinary illumination but are, however, visible under the microscope. It is this type of flaw that is responsible for the sudden changes in "brittleness" that are encountered in actual production.

The instrument that was described was designed primarily to demonstrate variations in the tensile strength of small diameter glass tubing. By means of this simple mechanical device, it can be shown that certain lots of tubing are "strong" and that other lots are "weak" or "brittle." Furthermore, the instrument can be used to assign a Factor of Merit to various production lots so that it is possible to compare different lots of tubing with respect to "strength" and "brittleness." In this brittleness testing device, the glass tubing is subjected to a bending moment for a definite interval of time. This is accomplished by developing the bending moment by means of three steel rollers and translating the strain along the length of the tube under test by moving the tubing relative to the axes of rotation of the rollers which remain fixed with respect to the base plate. The tubing is moved by means of a clutch consisting of two

(*Continued on page* 646)

FIRE FINISHING OF BOTTLES WITH OXY-FUEL GAS FLAMES

Making perfect finishes on bottles is a real problem. Any chips, fins, deformations or other imperfections in the finish not only present a safety hazard to the bottle user, but they also permit escape or spoilage of the contents. As an aid to the solution of this problem, a technique, fire finishing with an oxy-fuel gas flame, has been developed which makes a smooth finish easily obtainable. Not only has fire finishing solved the problem of making perfect crown finishes, but its use causes no interruption in the bottle making procedure, and accomplishes the results in a few seconds' time.

Here is how the oxy-fuel gas flame does the job. Heat is directed over a limited area so that only those areas to be finished are affected. Because of this close control of the oxy-fuel gas flame, and the high-flame temperature, fire finishing is speedily accomplished. The real reason why the time is so short is because heat transfer from flame to glass is rapid. Because the efficiency of the oxy-fuel gas flame is high, little heat is wasted, and consequently small volumes of fuel gas and oxygen are consumed.

Fire finishing of bottles necessitates no changes whatsoever in the operation of bottle making machines which employ rotating tables and take-out arms. Although the equipment in its present form is not interchangeable, the principle can be applied to any type of bottle forming machine. No extra conveyors are required. The simple, compact equipment for mixing and burning the fuel can be easily installed on any bottle making machine which operates with a rotating take-out arm for transferring the bottle from blow table to the conveyor.

Included in the fire finishing equipment, as developed by The Linde Air Products Company, are special regu-

(*Continued on page* 661)

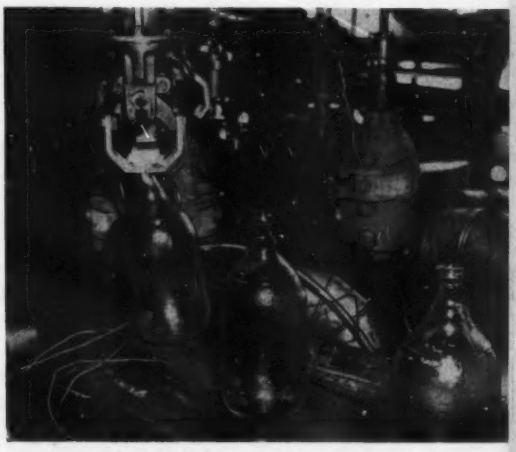
The oxy-fuel mixture is supplied to the double port valve (center of photographs) through a flexible metal hose. The valve ports are so arranged that when the bottle is picked up from the mold, the port allows the mixed gas to flow and ignite on the red hot bottle top. The flame continues to burn for the complete 180-deg. swing and then shuts off just before dropping the bottle on conveyor. At this time the other head has just picked up a bottle and the gas will be supplied to it for fire finishing through its 180 deg. swing. Highest economy is achieved because oxygen and fuel gas do not flow to the heads during the 180 deg. return movement, during which the take out fingers are empty. The cross arm operates counter-clock. This complete cycle shown is from 3 to 5 seconds in duration, or from 1.5 to 2.5 seconds per bottle produced.

Left: **Left head—mold just opening and fingers ready to pick up bottle. Right head—the 180-deg. fire-finishing swing has just been completed. The flame has been extinguished before dropping of bottle on conveyor.**

Lower Left: **Left head—fingers have picked up and are lifting bottle. The flame is about to come on. The clearance between fire-finishing head and bottle is about 5/16 in. during the finishing operation. Right head—fingers have just dropped bottle on conveyor.**

Lower Right: **Left head—Flame has just come on. The 180-deg. swing to conveyor will now be made. Right head—This head is idle; there is no flame.**

Right: **Left head—The swing and fire finishing are almost completed. The flame is about to go off, and the bottle will be dropped on conveyor. Right head—This is over the mold; the next bottle will be picked up.**



SURFACE ATTACK AND FLAKE FORMATION IN CONTAINERS

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TRANSLATED AND SUMMARIZED FROM THE BULLETIN DE L'INSTITUT DU VERRE (PARIS) FOR FEBRUARY, 1948

By DR. N. J. KREIDL
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I. The Dissolution of the Glass Surface

The attack of water and aqueous solutions on glass surfaces dissolves all the constituent elements in proportions which, in general, differ from the glass composition. As a matter of fact, the alkali elements (Na and K) immediately reveal their presence by the increased alkalinity which is determined easily by classical methods or the increased pH of the solution.

The alkalinity of the liquid and the quantity of the substances dissolved attract the attention of both producers and users in their endeavor to develop and test the most suitable glasses. On principle, the glasses should, of course, be attacked as little as possible by the liquids which are normally in contact with them. The following factors must be considered: composition of the glass, duration of contact, nature of liquid, concentration of solution, temperature, thermal shock, relation between container surface and volume of liquid, state and shape of glass sample (powders and fresh surfaces reveal the behavior of the internal mass rather than the active surface), degree of quenching or annealing of glass, surface condition, etc.

Because of the multiplicity of these factors neither the number of methods nor the contradictory results are surprising.[1] The assiduity of the search for so-called "neutral" glasses for the manufacture of ampuls or containers of pharmaceutical products is generally appreciated. The criterion of such "neutral" glasses is great resistance towards water and certain solutions. The testing method established in France by the "Commission Permanente du Codex" has been legalized by the decrees of November 8 and December 31, 1946, replacing the paragraph on "Testing Glassware," vol. II, p. 58 of the Codex Medicamentarius Gallicus of 1937. The following official text has been published in the Supplement 1947 of the Codex 1947, p. 47:

"Ampuls: Replace the paragraph 'Testing Glass Ware' by the following paragraphs:

"Test of Hydraulic Resistance

"The following test procedures apply to flasks and ampuls destined to the preservation of injectable medicaments. They may be applied equally to glassware used in the preparation of these medicaments.

"I. The tests are to be carried out with a liquid obtained as follows: Fill with double-distilled water, neutral (bromothymole blue R) a number of flasks or ampuls sufficient to obtain after sterilization, about 2500 cc. of liquid. Seal. Keep for 1 hour at 120°C. in an autoclave. Cool. Recover the liquid by opening flasks and ampuls.

"II. Take 100cc of the liquid and determine the alkalinity using $\frac{N}{100}$ sulfuric acid solution in the presence of bromothymole blue (R). The volume of the $\frac{N}{100}$ sulfuric acid solution used should not exceed 2cc.

"III. In a capsule of flat bottom and vertical sides, of 7cm. diameter, previously dried, evaporate at 100-105°C, in successive portions, 100cc. of the liquid to weight constancy. Evaluate residue P. Make a blank test under the same conditions with double-distilled water, neutral (bromothymol blue). Evaluate residue *p*. P—*p* should not exceed .003g

"IV. Add to 5 cc. of the liquid 5 cc. of hypophosphoric reagent (R) and heat 30 minutes above boiling in a double boiler. No brown color (arsenic) should be observed.

"V. Add to 10 cc. of the liquid one drop of HCl conc. and pass H_2S–. No brown color (lead) should be observed.

"Any flasks or ampuls failing these tests should be rejected."

The intention of the Commission, then, has been the measurement, under service conditions, of ampuls and flasks destined to receive medical solutions; and not the measurement of an intrinsic resistance of glass as a material. The limit of tolerances simply refers to 100cc. of the liquid contained in the ampuls assayed. Under these conditions the problem of the relation surface of ampul: volume of liquid is eliminated; however, within the limits of the influence of this factor the glass must be chosen with due consideration of the capacity of the container; the better glass being required for smaller ampuls.[2]

The Commission has not retained the pH determination. It has substituted the alkalimetric titration by $\frac{N}{100}$ H_2SO_4. The correct determination of the pH variation would require the use of double-distilled water and exact control of the CO_2 content.[4]

Among the most recent studies of this subject, the paper by Hinson, Smith and Greene[3] supplies data on five ampul glasses currently used in the USA. The compositions of these glasses are given in Table 1. The

TABLE I

GLASS ANALYSES

	N-51 A (a)	Pyrex Brand (b)	Iena Violax (c)	Amber 45 (a)	R-6 (c)
SiO_2	74.54	80.63	66.52	66.48	67.56
B_2O_3	9.46	12.84	8.41	8.63	1.35
Al_2O_3	5.52	2.18	10.47	7.27	2.97
BaO	2.30	—	—	—	2.12
CaO	0.87	—	5.45	1.93	5.63
MgO	0.14	—	0.19	1.46	3.98
Na_2O	6.42	3.53	8.61	7.46	15.24
K_2O	0.58	0.41	0.22	2.12	1.41
MnO	—	—	—	2.05	—
Fe_2O_3	—	—	—	2.19	0.04

(a) Kimble Glass Co.; (b) A. Thomas Co.; (c) Fish-Schurman Corp.

glasses were examined after a treatment of 30 min. at 120°C in the autoclave, as well as after storage of 2 years at 21°C, preceded or not preceded by autoclave treatment. The time was noted which is required for the formation of solid flakes in suspension. This phenomenon will be considered in the present study.

The results obtained with distilled water are reproduced in Table 2. The best performance was exhibited

TABLE II

GLASS	Increase in pH after 30 min. in autoclave at 121° C	Storage 2 years at 21° C: Increase of pH Auto-clave	Increase of pH Non-Auto-clave	Dry Extract x 10^{-6} Auto-clave	Dry Extract x 10^{-6} Non-Auto-clave	Months until Flake Formation Auto-clave	Months until Flake Formation Non-Auto clave
N-5 I A	1.2	1.2	1.0	4.9	4.7	No flakes	No flakes
Pyrex Brand .	1.5	1.5	1.3	10.2	9.2	"	24
Iena Violax .	1.5	1.6	1.4	11.6	9.5	24	24
Amber 45 ...	1.7	1.7	1.5	10.6	3.7	12	12
R. 6	3.5	3.3	3.2	97.5	102.0	0	12

by glass N51-A which did not deposit any flakes after two years of storage, with or without preceding autoclave treatment. Except for the Pyrex brand glass, N51-A contains more silica, boric acid, and barium oxide, and less alkali, lime and magnesia than any of the other glasses. Its alumina content is average. None of the glasses contains zinc oxide.

In the same vein the extensive study of O. Richter[4] on the importance of glass in plant physiology and biology should be called to the attention of glass technologists, physiologists and biologists. The complete title of the reference may serve as the only comment in this discussion.

Finally, it may be considered common knowledge that elements dissolved from the interior surface of a container may cause reactions in chemical solutions, particularly of alkaloids, and originate harmful precipitates or processes.

II. Flakes as a Product of the Deterioration of Glass Surfaces

The strictly "chemical" consideration of the surface changes of glass and their influence upon the preservation of stored liquids is not the only important one. Upon attentive examination sooner or later, the formation of soluble particles is observed frequently. They are flat, float in the liquid and diffuse light brilliantly.

The examination by a magnifying glass, at magnifications of the order of 20 to 50, reveals that the flakes most frequently are found in the shape of an eyelash, sometimes flanked by a very thin, flat surface. Because of their mobility it is difficult to indicate their exact size, but many particles exceed 100 microns (.1 mm). Others may be as small as one micron (.001 mm) or less.

Autoclave treatment, particularly at elevated temperatures, accelerates their formation. In 1907, Gruebler[5] studied sterilization procedures in poor glasses and the occurrence of "silica turbidities" as the consequence of alkali losses. In 1925 Mauri[6] studied four glasses the composition of which is given in Table 3. After 2 hours

TABLE III

GLASS	SiO_2	B_2O_3	Al_2O_3	CaO	Na_2O	ZnO
A	66.60	6	10.90	8.10	8.09	—
B	74.70	5	7.30	3.00	9.73	—
C	68.35	11.11	4.70	2.50	6.86	6.0
D	65.50	12.0	1.17	4.01	8.00	9.0

at 180°C in the autoclave the contents of ampuls A and B remained clear. In glasses C and D turbidity appeared at 134°C and at higher temperatures flakes were seen floating in the liquid. Table 4 shows the influence of heating time.

TABLE IV

GLASS	2 h.	4 h.	8 h.	16 h.	32 h.
A	L	L	L	L	Little attack
B	L	L	L	L	L
C	P	PP	PP	PP	PP
D	P	PP	PP	PP	PP

L = clear; P or PP = flakes.

Flake formation is not limited to water and aqueous solutions. It is also observed when certain glasses are exposed to alcoholic solutions. Turner[7] observed flake formation from four English bottle glasses after exposure for six days and at 30-60°C to a 40% alcoholic solution; and after 2-5 days exposure to distilled water at 60°C or 5-11 days exposure to distilled water at 30°C. More recently Bacon and Burch[8] studied this type of attack on ten bottle glasses typical of USA production somewhat before 1940.

At 75°C, flakes appeared in seven types after having been in contact with alcoholic solutions from 0-60% for 1-6 days; in the autoclave distilled water produced them at 120°C in 6 bottles after 1 hour, in 8 bottles after 5 hours.

Only two glasses released no flakes after 14 days at 75°C in Alcohol or water, nor in 5 days at 120°C in the autoclave. These glasses contained:

	Wt % I.	II.
SiO_2	70.2	71.3
Al_2O_3*	2.9	3.2
CaO	9.97	9.65
MgO	.28	.83
BaO	.11	.11
Na_2O	14.8	12.7
K_2O	1.7	1.9
SO_3	.06	.12

Glass II started to release flakes at 130°C.

* + Fe_2O_3.

In each experiment the soluble and insoluble substance extracted from the glass were determined. Similar determinations were made after exposure to gin since it had been believed that the alkali extracted by distilled water in the autoclave permitted a prediction regarding flake formation in gin. The studies of Bacon and Burch proved, however, that this assumption is incorrect. The bottles causing no flake formation in gin were among those exhibiting notable alkali losses.

The following conclusions of these authors should be emphasized: (1) Usually, but not always, flake formation decreases with the concentration of alcohol. (2) The alkali loss is not an indication of probable flake formation. (3) There is no straightforward relation between the resistance to distilled water between 75°C and 121°C and the resistance to alcohol between room temperature and 75°C.

The general conclusion from the work discussed so far must be that flake formation in aqueous and alcoholic solutions is a specific phenomenon not connected in a simple manner with the alkali loss of the surface. The phenomenon is of no small concern to manufacturers of bottles for the liquor industries. Only recently a foreign customs office has refused the entry of an important shipment of alcoholic beverages contaminated by flakes.

III. Physiological Effects of Flakes on Animals

The formation of flakes will also concern the manufacturers of pharmaceutical glassware because of the possibility of pathological effects caused by injection or ingestion of contaminated medical solutions.

In 1933 Stantial and Dolan in the course of a study of various forms of silicosis[9], administered intravenous injections of silica to dogs, who died subsequently.

At the same time Gardner and Cummings[9] subjected rabbits to intravenous injections of silica particles of various size, which were recovered in the autopsy. The smallest particles caused grave disorders. In 1937 and 1940 Simpson[9] obtained similar results.

The importance attributed to the subject by American specialists can be seen on perusal of the report presented by J. H. Brewer and J. H. F. Dunning at the annual meeting of the American Drug Manufacturers[9]*. In the preamble of this report mention is made of the possibility of an emboly being caused by the intravenous injection of medications containing flakes. Since the absolute freedom from glass contamination is impossible in solutions prepared and sterilized in ampuls it seemed important to know the limitation of this hazard. Frequent and concentrated injections of coarse particles were found to cause damages in various parts of the animal body. When, however, glass diluted to resemble the habitual pollution was used, after filtering of exceedingly large particles no lesions were found and pathologists verified the entirely normal condition of the test rats. In another large series of experiments the centrifugate from ampuls manufactured regularly and rejected for contamination by particles was injected with no cases of death or permanent damage. For the portent of their conclusions reference should be made to the original context of the report. The authors while admitting the needs for a vigilant attitude towards possible damages caused by the injection of silicious contaminations on the part of the ampul manufacturer appear to believe that the manufacturer will, in general, not have to fear that a solution free from contamination to the naked eye will cause emboly even if occasional particles remain present. On the other hand he has to be watchful of a larger amount of ultra-fine particles below 1 micron which escape all but special filters.

TABLE V

	A	B	D	E
SiO_2	71.4	70.2	77.5	71
B_2O_3	3.4	1.4	6.0	1
Al_2O_3 + Fe_2O_3	8.4	8.1	4.8	3
BaO	—	—	3.6	—
CaO	2.9	3.9	0.3	4
MgO	0.6	1.1	0.2	1
ZnO	2.5	2.3	—	2
Na_2O + K_2O	10.7	12.8	7.4	17
Miscellaneous	0.1	0.2	0.2	1

It is difficult to evaluate these studies and the conclusions reached from animal tests in regard to human beings. This is why the reference to the original text seems important. It must be admitted that in spite of a certain optimism based on their experimental results the authors concede inherent dangers in the contamination by particles.

It cannot be denied that there subsists a grave doubt as to whether the particles ingested with drinks or injected with pharmaceuticals are harmful and that it is desirable to utilize glass which does not give rise to flake formation in the autoclave or after a reasonably long time of storage. Such glasses appear to exist; at least there are 1) the glass N-51A studied by Hinson, Schmidt and Green, 2) the bottle glass studied by Bacon and Burch, 3) Mauri's glasses; and, perhaps, many other so-called "neutral" glasses.

IV. Experimental Part

Since 1946 the French Glass Institute has been impressed with the urgency of the ampul problem by people working in intimate liaison with the best medical and public authorities and has immediately started upon a program of research.

The aim of the experimental researches at the Institute was principally to study, in aqueous media, the formation and, possibly, the very nature of flake formation as a function of the glass composition. The alkalinity produced in the liquid was not considered the essential phenomenon.

These researches were undertaken under the direction of the Institute by M. Rene Sanselme, in the laboratories of the Chemical Institute at Chermont-Ferrand, with the kind permission of its director, M. Rambaud.

All glasses were shaped into ampuls of about 15 mm. diameter and 30-35 cc. content. In the microscope no surface cracks etc. appeared in normal or dark field illumination. The thermal treatments were conducted in the autoclave.

A. The Action of Water. The tests in double-distilled water at 145°C-150°C in the autoclave gave the results tabulated in Table VI. In the case of flake formation

* The translation of the following section is abbreviated since it draws widely from the article (9) in "Glass Packer" which is available to the readers of GLASS INDUSTRY.

TABLE VI

GLASS	Flakes in	Reaction of Liquid	Observations
A	15 h.	Little Alkaline	
B	2 h.	Alkaline	More flakes than in A
D	—	pH unchanged	No flakes like
E	2 h.	Very alkaline	in B

there was always found an alkalinity corresponding to $\frac{N}{1000}$ NaOH, i.e. .031 g/liter of Na_2O. As long as the glass was attacked, silicates were detected by the yellow silico-molybdic reaction.

B. The Action of Alkaline Solutions. If, in the place of distilled water $\frac{N}{1000}$ or even $\frac{N}{2000}$, soda solution is used, the flake formation is accelerated. With glass A and $\frac{N}{1000}$ NaOH flakes appear in 1.5 to 2.0 hours at 145°C, compared to 15 hours in the case of distilled water. The alkaline solution brings glass A into the class of glass B. Glass D shows no flake formation whether water or $\frac{N}{1000}$ NaOH is used. It appears that flake formation has to be preceded by the dissolution of alkali in a concentration of the order of $\frac{N}{2000} - \frac{N}{1000}$. A solution of .05 mol of borax per liter yields results comparable to $\frac{N}{1000}$ soda. $\frac{N}{1000}$ baryta promotes some turbidity but no flakes. Sodium silicate in very weak concentrations prevents flake formation, even in glass B. Urotropin (hexamethylen tetramin) from 5-10% prevents any discharges in glasses A or B.

A heat treatment of glass A near its softening temperature was undertaken in the hope of causing some alkali to the surface, but did not modify the formation of flakes. A $\frac{N}{1000}$ soda solution affects the internal surface of glass A in 2-3 hours at 150°C and causes a turbidity apparently consisting of very small conglomerated flakes. Such conglomerations are often observed at higher pH and in the presence of a large number of flakes. Agitation dissociates the agglomerates and restores the normal appearance of the flakes. With glass D .077 N soda gives a blemish, but no flakes.

C. The Action of Acidic Solutions. It had been stated that a certain quantity of alkali is necessary for flake formation. This appears to be confirmed by tests with acidic solutions. When, for instance, ampuls B were filled with $\frac{N}{1000}$ HCl, a treatment for 3 hours in the autoclave, failed to provoke any flake formation at 145°C. One-third of the acid was found neutralized by the alkali coming forth from the glass. This amount corresponds to only one-third of the alkali formation observed in the case of pure water. The same ampuls washed and refilled with distilled water did not give a new discharge in 8 hours (while 2 hours were sufficient in the case of ampuls not pretreated by acid). The surface must have been deprived of some of the alkali which has to be liberated to start flake formation.

Similarly, distilled water containing a remainder of CO_2, did not promote flake formation; or at least promoted flake formation later or in smaller quantities. Nitric acid equally inhibited the attack.

When an ampul was washed first with cold concentrated hydrochloric acid, then with distilled water, flake formation was not prevented but the flakes were not easily detained from the internal wall.

When an ampul made of glass B containing its liquid and its flakes received $\frac{N}{50}$ to $\frac{N}{100}$ HCl the flakes disappeared. The liquid appeared clear but was found turbid when examined in an arc lamp.

D. The Action of Dissolved Silicates. Sodium silicate added to water in an ampul prevented the formation of flakes. In order to explain the inhibitive action of silicates the flakes had been assumed to be soluble in sodium silicate and to dissolve upon formation.

When, however, sodium silicate was introduced into an ampul B containing its water and its flakes and the system was treated in the autoclave no alteration of the flakes was observed. When the flakes were centrifuged, washed and reintroduced into the ampul B, in a suspension containing some sodium silicate they remained unchanged, although a slight turbidity ensued.

When an ampul made from glass B was filled with water first treated in the autoclave in Glass D—which does not form a discharge but passes silicates into the solution—no discharge was obtained.

The silicates, however, which are dissolved from glasses A or B did not prevent flake formation in the concentration in which they occur. As a matter of fact, if the liquid of an ampul giving flakes was filtered, new flakes appeared.

In conclusion, sodium silicate added to the solution in the ampul prevents flake formation but does not decompose them once they are formed.

E. Process of Flake Formation. The solid particles which later pass into suspension originally separate from the wall on cooling in the form of a coherent layer covering the entire interface liquid-glass in the ampul, extending a few millimeters above the level of the liquid. This upper part of the layer extending above the level of the liquid frequently remains glued to the glass. If this part of the ampul is examined under a powerful lateral source of illumination (sun, arc-lamp), the area in which the layer remains stuck to the glass appears slightly bluish while the main area from which the layer has become detached does not exhibit any diffusion. Similarly, there is no diffusion beyond the few millimeters above the level of the liquid. There, no flakes had been formed at all since the liquid did not rise that high.

In dark field illumination the microscopical examination of the coherent layer as well as of the dried particles seems to reveal a granulous structure at 890 magnification, the grains measuring about one micron. Because of their small size it is impossible to decide by means of the polarizing microscope whether they are crystalline.

Flakes lying flat on a plate glass exhibit the blue-green interference color (about 500 millimicrons) of the first order. Assuming an index of $n = 1.4$, the thickness is equal to 1.4 times one fourth of the wave length i.e. about .1 micron.

If one attempts to promote the attack on the external

surface of the ampul by placing a closed ampul in a transparent fused silica tube containing water and exposing the system to the autoclave treatment, one finds that the layer does form at the external face; but it is not detached spontaneously, and cannot be detached by agitation. This phenomenon is also observed if ampuls consisting of B glass are used in Dewar vessels: a surface skin forms on the external surface but is not detached.

Another experiment shows somehow the mode of formation of these flakes: one shapes an ampul, half glass B, half transparent silica, united by plane polishing and held between plates of sheet iron with rubber in-between. The ampul is held so that glass B is on the bottom, and only this part is filled with water. The ampul is subjected to autoclave treatment at 150°C for 3 hours, then the ampul is turned over, silica on the bottom. After cooling one finds the layer on the inside of glass B to which it continues to adhere.

This procedure of turning over the ampul was also applied to an ampul made of B entirely, but filled only half. In the half exposed to the liquid during the hot treatment the layer formed and remained adherent on turning over and cooling. In the half which was in contact with the liquid only during the 15 minutes of cooling very few flakes were found afloat. Brutal and lively refrigeration such as by dry ice and acetone does not detach the layer once formed without detachment.

In conclusion it may be stated: (1) The flakes form during the contact of the liquid water (not the vapor) with the glass. (2) The flakes separate when the wet surface cools rapidly. (3) The flakes derive from the initial formation of a fragile coherent layer which is torn by convection currents and may be reduced to a dust of flakes by a minimum of agitation.

F. The Nature of the Flakes. A lot of 162 ampuls of 30cc., consisting of glass B, was treated in the autoclave at 150°C for 3 hours (excluding ½ hour for heating and ¼ hour for cooling). The decanted flakes were centrifuged, washed first in alcohol at 95°, then in ether and dried in a stream of warm filtered air. About 100 mg. of flakes were recovered and analyzed. The results are contained in Table 7.

TABLE VII

	Hydrated Flakes Per Cent	Ignited Per Cent
SiO_2	35.0*	42.6*
B_2O_3	0	0
Al_2O_3 + Fe_2O_3	18.5	22.6
CaO	2.5	3.1
MgO	3.0*	3.7*
ZnO	10.5	12.8
Alkali	12.5*	15.2*
Ignition Loss (750°)	18.0	—

*Approximately

The evaporation of 100cc. of the filtered solution of B, free of flakes, gave a dry extract of 23.2 mg. The concentrated solution as well as the residue were reddish. The presence of B_2O_3 and Fe_2O_3 was shown by the green flame of the methylborate ether flame and the ferrocyanide reactions respectively.

Since on the other hand about 4500cc. of liquid B gave 100 mg. of hydrated flakes, or 80 mg. of glassy matter, 100cc. contain 1.8 mg. of flakes calculated as glass. The grand total of the dry extract from 100cc. then would amount to 1.8 mg. flakes and 23.2 mg. soluble, i.e. 25.0 mg. The dissolved matter then has about 13 times the weight of the flakes. This ratio compares with 4-16 found by Bacon and Burch in 19 different glasses.[8]

From these data, the known composition of glass B and the analysis of the flakes one can calculate the approximate proportion of the elements dissolved and compare them with the proportions present in glass B and the flakes (Table 8).

TABLE VIII

	Composition in Per Cent of Glass B	Flakes	Dissolved	Per Cent Attacked in Glass B	Dissolved Glass Composition in Per Cent	Flakes in Per Cent
SiO_2	70.2	3.2	67.0	95	72.4	42.6
B_2O_3	1.4	—	1.4	100	1.5	0
Al_2O_3	8.1	1.6	6.5	80	7	22.6
CaO	3.9	0.2	3.7	95	4	3.1
MgO	1.1	0.2	0.9	78	1.0	3.7
ZnO	2.3	0.9	1.4	60	1.5	12.8
Alkali	12.8	1.2	11.6	92	12.6	15.2
	99.8	7.3	92.5		100	100

This table shows that resistant elements of glass B are, in decreasing order, : ZnO; then MgO and Al_2O_3; then SiO_2, CaO, alkali; finally B_2O_3.

V. Conclusion

The surface disintegregation of glass, by aqueous solutions which become manifest by the dissolution of its elements is frequently accompanied by the formation of insoluble particles which may be harmful or doubtful in their effects, particularly, in the storage of medicines in ampuls or vials, or of beverages.

The determination of the alkalinity and of the harmful elements dissolved is carried out by known methods, particularly those of the Codex Med. Gallicus in France.

The studies of M. Sanselme and of the authors cited in this paper make apparent the following principles covering the formation of insoluble particles:

a) The formation of flakes is a specific phenomenon. It is not quantitatively related to the surface loss of alkali, but the presence of alkali in the solution is associated with it. It is accelerated by a $\frac{N}{1000}$ concentration of Na_2O or borax. Certain solutions, however, such as of acids or sodium silicate if diluted or of urotropin seems to retard it.

b) The formation of flakes depends upon the composition of the glass, but for practical purposes strict limitations can not be set up, if such should exist, because of the complexity and variety of glass formulations. One may assume that a certain alkali content is favorable; but none of the conventional constituents —not even ZnO—is a specific antidote, since one finds more or less all of them both in the solution and the flakes.

c) The formation of flakes is accelerated by the treatment in the autoclave. But the equivalence, if any,

(*Continued on page* 658)

INTERFACIAL MICROREACTIONS IN GLASS MELTS

By H. JEBSEN-MARWEDEL

PART II

Chemical Reactions in Interfaces

The interfaces in an inhomogeneous melt are not only the basis of diffusion processes but may be recognized as the locations of chemical reactions involving gas formation. Carbon amber in contact with colorless glass containing SO_3 is an example suitable for demonstration. This contact occurs in practice by variations in reduction or the introduction of cullet containing SO_3. The compound $2NaFeS_2$ is believed to be the colorant of amber glass. Its reaction with SO_3, $2NaFeS_2 + 11SO_3 = 2FeO + Na_2O + 15SO_2$, is connected with violent evolution of gas and often responsible for fining difficulties.

In the preparation represented in Plate XII, a hypocycloidal space may be recognized. The spreading skin is disclosed by a star-like arrangement of bubbles. The correlation between the form of distribution and the field of reaction is striking. Whether brown particles are surrounded by colorless areas or vice versa, bubbles are formed at the interface (Plate XIII). Bubbles also occur inside splitting zones and confirm the suggested mechanism in which molecular forces participate in the chemism of the reaction.

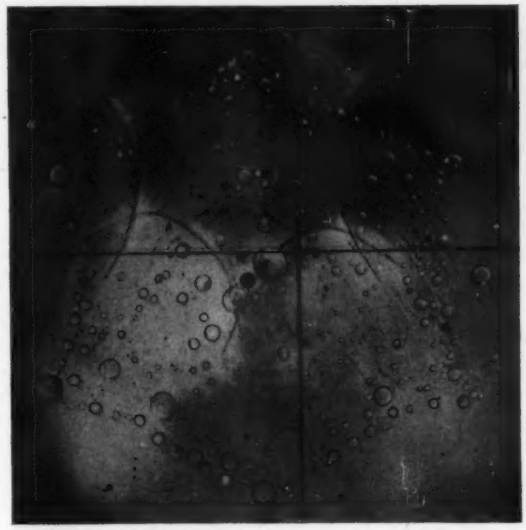
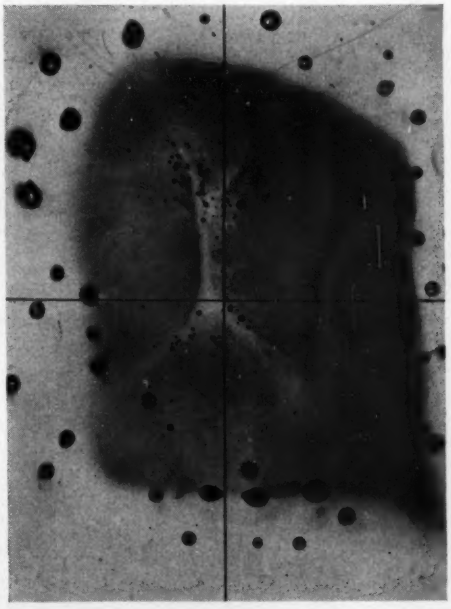


Fig. 12. Spacial element with concave areas (upper half) produced by the spreading skin of reaction bubbles in star-like arrangement. (Light weakly polarized to make visible hypocycloid by strain on interfaces.)

Persistence of Former Surfaces in Inhomogeneous Melts

The former free surfaces of particles constituting a melt persist in the internal structure of this melt (Plate VII—ref. 11). If the former free surfaces had been exposed to specific chemical influences, the structure is particularly well developed. Leaching by water leads to visible interfaces. Exposure to gases, even traces of $SO_2 + O_2$, leads to a striking stronger separation, and a network of strains (Plate XIV) coinciding with these interfaces becomes manifest in the frozen melt (Plate XV). Significantly, the intensity of these strains decreases if the parts exposed to gases are subsequently leached by water. This indicates the instability and accessibility of SO_3 in the surface. Only fresh pieces of glass fuse without any



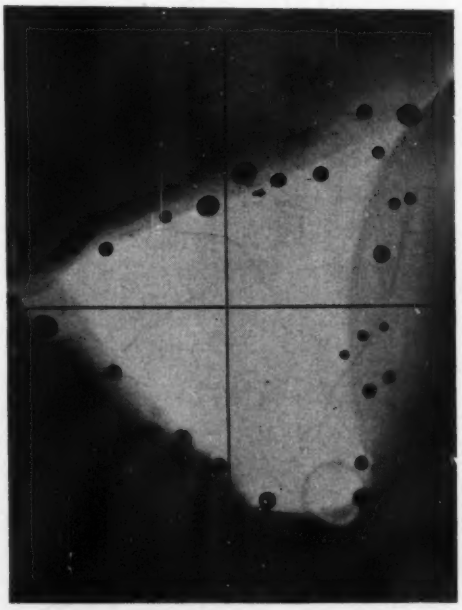


Fig. 13. Sulfur amber spherical cord in colorless glass, and colorless spherical cord in sulfur amber glass. Reaction bubbles occur at interfaces and in the brown area split by the clear glass.

Fig. 14. a) Cells of cord in a melt consisting of preformed but equally composed volume elements. b) The same preparation in polarized light. Considerable strain along the cell boundaries.

Fig. 15. Volume elements of a melt the free surface of which had been exposed to SO_2 and O_2 at 500°C. suffer such strain when united at 1000°C. that fracture occurs invariably. The cellular character of the melt is just recognizable in the center area.

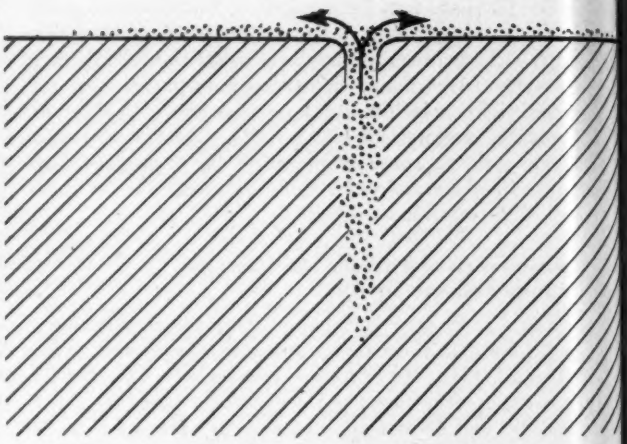
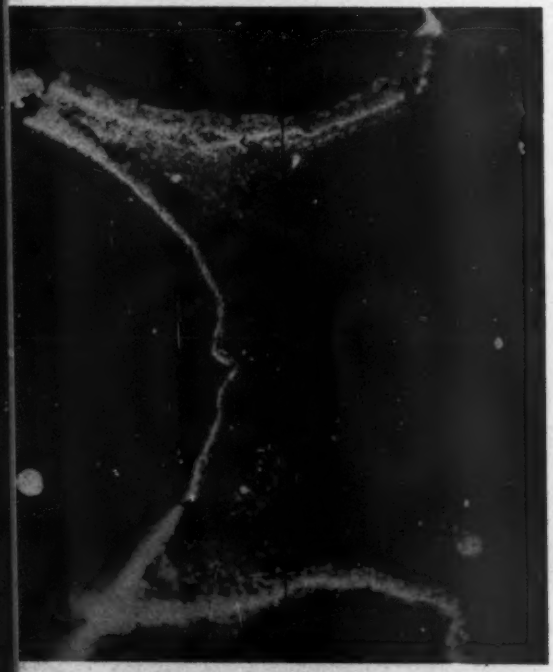


Fig. 16. Glass gall (Na_2SO_4) leaves through capillary interstices with oversaturated faces by means of adhesion. Reversed process of Fig. 5.



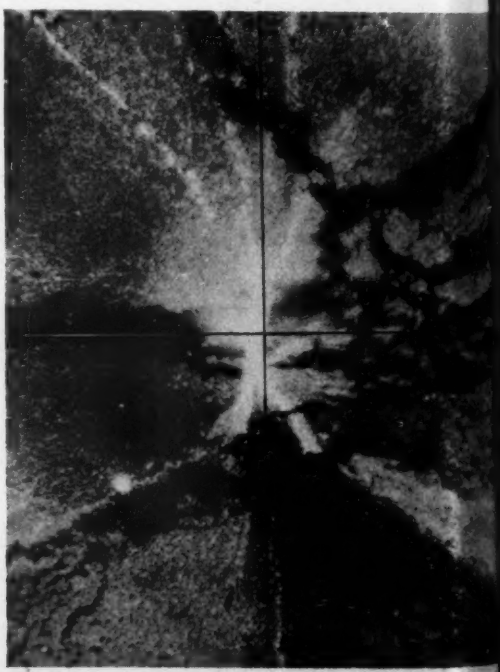


Fig. 17. Formerly free surfaces exposed to sulfuric gases secrete sulfate alongside cellular walls (left). The sulfate then coats the entire surface (right). At the cross-hairs a center of secretion.

Fig. 18. Cell of cord spreads like a skin over cells of larger surface tension. It penetrates in direction of arrows. The film of cord (vertical on figure) pushes a bubble.

trace of the former surfaces. This observation is important in lamp working. For similar reasons, a melt from cullet alone suffers from the fact that the surfaces of the cullet pieces introduce an "envelope" of cords.

Sulfate in Interfaces

It is known that a glass melt may dissolve as much as one per cent of sodium sulfate. The exposure of SO_2 and O_2 need not become manifest. Traces of sulfur from combustion gases may saturate the surfaces of cullet with sulfate.

If such surfaces are incorporated in the melt, e.g., in an experimental fusion of glass spheres exposed to gases, the interfaces formed are supersaturated with sulfate. They expel the sulfate not by means of diffusion but by the action of surface forces (Plate XVI). The process is the reverse one of Plate III-b. The sulfate escapes along the interfaces (Plate XVII) to the surface where it is seized and disintegrated by the reducing atmosphere. If the disintegration lags behind the supply through the "seams," glass gall forms and spreads on the surface in the form of a fine veil. The process thus appears dominated by surface tension.

Recently Weyl[9] has emphasized the role of the surface of glass. Considerations of this kind are well in order in the discussion of the external and internal interfaces of the unfinished melt. The small quantities of sulfate adsorbed at former free surfaces, for instance, suffice to incite the process of unmixing. Glass melts entirely free of added sulfate, as well as glasses prepared exclusively from cullet, may develop glass gall as the sole consequence of exposure of former free surfaces to combustion gases.

The establishment of the equilibrium

$$\frac{2SO_2 + O_2 \text{ (atmosphere)}}{2SO_3 \text{ (melt)}}$$

is not exclusively a chemical process but depends upon the mechanism of the establishment of physical equilibria directed by surface forces.

Bubbles and Interfaces

The arrangement of bubbles in the melt is not independent of the location of interfaces. Plate XVIII illustrates a bubble pushed ahead by a film of cord material while the film penetrates other elements of the melt. In Plate XIX five bubbles remain connected with the original cord by a "hose." The "hose" consists of sulfate. The segregation of sulfate evidently may influence the transportation of bubbles. Finally, each bubble adjacent to an interface represents a third phase and solicits capillary spread of elements of smaller surface tension during the fining period.

Prospects

This study reveals a host of microscopic observations deserving of further exploration. The microscopic method

(*Continued on page* 660)

Fig. 19. Bubbles rising from cell cords remain connected to them by sulfate channels. Right: detail.

BORIC OXIDE—ITS CHEMISTRY AND ROLE IN GLASS TECHNOLOGY

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Part IX

References

Arndt, K. and Gessler, A., Electric Conductivity of Fused Salts, Ztschr. Elektrochemie *14*, 662-665 (1908).

Badger, A. E., Johnson, H. C. and Kraehenbuehl, J. O., Structure of Sodium Borate Glasses as Affected by Temperatures, J. Amer. Ceram. Soc., *25*, No. 14, 395-401 (1942). Cobalt ions are used as color indicators. Their light absorption is affected by surroundings and temperature. An attempt is made to interpret the colors of various sodium borates containing cobalt oxide on a structural basis.

Bastress, A. W., The Fields of Glass Formation II. The Alkali Borates, Glass Science Bull. IV., 133 (1946). The composition field of glass formation can be widened by using a mixture of alkali ions.

Baumann, H. N. and Moore, C. H., Electric Furnace Boro-Aluminate, J. Amer. Ceram. Soc., *25*, No. 14, 391-94 (1942).

Baumgarten, P. and Bruns, W., On the Reaction of Boron Trifluoride with B_2O_3, Borates, Carbonates and Nitrates, Ber. Deutsch. Chem. Ges., *72*, 1753 (1939), *74*, 1232 (1941). Formation of a boron oxyfluoride is used for replacing oxygen ions by fluorine in a variety of compounds.

Besborodov, M. A. and Silberfarb, L. M., Study of the Chemical Reaction in the Melting of Potassium Borosilicate Glasses, J. Soc. Glass Techn., *14*, 39-51 (1930).

Bezzi, S., Thermal Dissociation and Vapour Pressure of Boric Acid and Its Volatility in Steam, Annal. Chim. Appl., *25*, 121-122 (1935), From Brit. Chem. Abs. *-A*, 817 (1935).

Bezzi, S., Vapour Pressure and Thermal Dissociation of Ortho-Boric Acid, Cazzetta Chim. Ital., *65*, 766-772 (1935).

Biscoe, J., Pincus, A. G., Smith, S. S., and Warren, B. E., X-ray Study of Lime Phosphate and Lime Borate Glass, J. Amer. Ceram. Soc., *24*, 116-119 (1941).

Biscoe, J., Robinson, C. S. and Warren, B. E., X-ray Study of Boric Oxide—Silica Glass, J. Amer. Ceram. Soc., *22*, 180-184 (1939).

Biscoe, J. and Warren, B. E., X-ray Diffraction Study of Na_2O-B_2O_3 Glasses, J. Amer. Ceram. Soc., *21*, 287 (1938).

Bleininger, A. V. and Teetor, P., A Thermal Study of Boric Acid—Silica Mixtures, Trans. Amer. Ceram. Soc. XIV, 210-217 (1912).

Bradley, C. A., Measurement of Surface Tension of Viscous Liquids, J. Amer. Ceram. Soc., *21*, 339-344 (1938). The surface tension B_2O_3 is measured by the sessile-drop method.

Brewster, G. F., Kreidl, N. J. and Pett, T. G., Lanthanum and Barium in Glassforming Systems, J. Soc. Glass Techn., *31*, No. 142, 153-169 (1947). The field of glass formation in the system lanthanum oxide-barium oxide-boric oxide has been examined.

Carlson, E. T., The System CaO-B_2O_3, Journ. Res. Nat. Bur. Stand., *9*, 825-32 (1934). The phase diagram for the system CaO-B_2O_3 has been partially worked out.

Chu, G. P. K. and Weyl, W. A., Method for Determining the Water Content of Glasses by Means of Electrolysis, Glass Science Bull. IV, 144-147 (1946). Water is removed from fused borax by electrolysis.

Cole, H., Constitution of Alkali Halide-Borate Glasses, Nature *160*, 190 (1947). Critical discussion of results obtained by S. K. Majumdar and his own experiments.

Cole, S. S., Scholes, S. R. and Amberg, C. R., Properties of Anhydrous and Hydrated Metaborates of Sodium and Potassium, J. Amer. Ceram. Soc., *18*, 58-61 (1935).

Cole, S. S. and Taylor, N. W., Preparation of Crystalline B_2O_3 and Some of Its Physical Properties, J. Amer. Ceram. Soc., *18*, 55-58 (1935). The results presented in this paper are invalidated by later work by F. C. Kracek, Morey, G. W. and H. E. Merwin.

Cole, S. S. and Taylor, N. W., Vapour Pressures of Boric Oxide, Sodium Meta-borate, and Sodium Diborate Between 1150-1400°, J. Amer. Ceram. Soc., *18*, 82-85 (1935).

Cole, S. S., Taylor, N. W. and Scholes, S. R., The Optical Properties, X-ray Patterns and Melting Points of the Anhydrous Sodium Borates, J. Amer. Ceram. Soc., *18*, 79-81 (1935).

Cousen, A. and Turner, W. E. S., The Density of Boric Oxide Glass and the Atomic Weight of Boron, Journ. Chem. Soc., 1928, 2654-57.

Cousen, A. and Turner, W. E. S., Study of Glasses B_2O_3-SiO_2, Journ. Soc. Glass Techn., *12*, 169-190 (1928).

Curtis, R. M., Borax as an Accelerator in Glass Melting, Ceram. Ind., *29*, 445-448, 466 (1937).

Dane, E. B. and Birch, F., The Effect of Pressure on the Viscosity of Boric Anhydride Glass, J. Appl. Physics, *9*, 669-674 (1938).

Davis, H. M. and Knight, M. A., The System MgO-B_2O_3, J. Amer. Ceram. Soc., *28*, 97-102 (1945).

Day, A. L. and Allen, E. T., Carnegie Inst. of Washington Publ. No. 31 (1905). Observation of an endothermic effect in borax glass near 500° C.

Dietzel, A., Means to Accelerate Glass Melting, Glastechn. Ber., *21*, 198-204 (1943). Attempts to find a substitute for borax as a minor addition. Alkali titanium silicate is described as a possible accelerator of glass melting.

Dimbleby, V., Hodkin, F. W., Parkin, M. and Turner, W. E. S., A Study of the Melting and Working Properties of Boric Oxide Glasses With Special Reference to the Sodium Borosilicates, Journ. Soc. Glass Techn., *7*, 59 (57-72) (1923).

Dimbleby, V., Parkin, M., Seddon, E., Turner, W. and Winks, F., The Influence of Boric Oxide on the Rate of Melting and on the Thermal Expansion and Resistance to Weathering of Soda-Lime-Silica Sheet Glasses, Transactions J. Soc. Glass Tech., *18*, 13 (1935).

Dimbleby, V., Parkin, M., Turner, W. E. S. and Winks, F., The Effect of Boric Oxide on the Rate of Melting and On Some Physical Properties of Bottle Glasses, J. Soc. Glass Techn., *13*, 248 (1929).

Donoghue, J. J. and Hubbard, D., Thermal Expansion Studies of Boric Oxide Glass and of Crystalline Boric Oxide, J. Res. Nat. Bur. Standards *27*, 371-379 (1941).

Ebelmen, M., On a New Method of Obtaining Crystallized Compounds and Its Application to the Synthesis of Minerals, Annales de Chim. et Phys. *22*, 211, (1848), *33*, 34 (1851). The solvent power of boric oxides and borates is used for producing crystallized compounds. Effect of B_2O_3 as a mineralizer.

Eitel, W. and Dietzel, A., Use of Boric Acid in Window and Table Ware Glasses, Glastechn. Ber., *14*, 118 (1936). Report to the committee on raw materials. Observation on a Fourcault tank revealed that the addition of borax to the glass batch lowers the melting temperature. In one case each 0.1% B_2O_3 in the form of borax (B_2O_3 + Alkali) added, without further change in composition lowered the melting temperature nearly 10° C. Accordingly melting and firing properties are improved.

English, S. and Turner, W. E. S., The influence of Boric Oxide on the Annealing Temperature of Borosilicate Glasses, J. Soc. Glass Techn., *7*, 73-79 (1923).

English, S. and Turner, W. E. S., The Physical Properties of Boric Oxide Containing Glasses and Their Bearing on the General Problem of the Constitution of Glasses, Journ. Soc. Glass Techn., *7*, 155-169, (1923).

Enss, J., A Contribution to the Effect of B_2O_3 and ZnO on the Properties of Glass, Glastechn. Ber., *14*, 279 (1936).

Flint, E. P. and Wells, L. S., The System CaO-B_2O_3-SiO_2, J. Res. Nat. Bureau Standards, *17*, 727-752 (1936).

Foëx, M., Contribution to Solubility and Immiscibility in Glasses, Ann. Chim., *11*, 359-452, (1939). The solubilities of a large number of oxides in boric oxide and borates is discussed.

Geller, R. F. and Bunting, E. N., The System PbO-B_2O_3, Journ. Research Nat. Bur. Standards, *18*, 585-593 (1937).

Geller, R. F. and Bunting, E. N., The System PbO-B_2O_3-SiO_2, J. Res. Nat. Bur. of Stand., *23*, 275-283 (1939).

Gooding, E. J. and Turner, W. E. S., A Study of the Series of Glasses Containing Sodium Oxide, Boric Oxide and Silica, J. Soc. Glass Techn., *18*, 32-66 (1934).

Grebenshchikov, I. V. and Molchakova, O. S., Preparation of Microfilms on Sodium Borosilicate Glasses and Their Properties, J. Gen. Chemistry. U. S. S. R., *12*, 588-597 (1942).

Green, R. L., X-ray Diffraction and Physical Properties of Potassium Borate Glasses, J. Amer. Ceram. Soc., *25*, 83 (1942). The structure of potassium borate glasses as derived from X-ray diffraction patterns is correlated with their physical properties, expansion, density and viscosity.

Greig, J. W., Immiscibility in Silicate Melts, Am. Journ. Science *13*, 1-44 and 133-154 (1927). B_2O_3 and SiO_2 were found to be completely miscible.

Guertler, W., On the Limits of Miscibility of B_2O_3 and Borates in Fused Condition, Z. anorgan. Chem., *40*, 225-253 (1904).

Hall, F. P. and Insley, Herbert, Phase Diagrams for Ceramists, J. Amer. Ceram. Soc., Nov. 1947. This issue of the Journal contains all interesting phase diagrams having B_2O_3 as a constituent. It may be consulted for further references.

Harrison, Anna J., Water Content and Infrared Transmission of Simple Glasses, J. Amer. Ceram. Soc., *30*, 362-366 (1947).

Hibben, J. H., The Constitution of Some Boric Oxide Compounds, Amer. Journ. Science *35*, A 113-125 (1938).

Hood, H. P. and Nordberg, M. E., U. S. Pat. 2,106,744, 1938; 2,215,039, 1940; 2,221,709, 1940; 2,286,275, 1942; 2,315,329, 1943.

Hubbard, D., Hygroscopicity of Optical Glass As An Indicator of Serviceability, J. Research Nat. Bur. Standards *36*, 365-375 (1946).

Humphrys, J. M. and Morgan, W. R., Effect of Composition and Thermal History on Dielectric Constants of Soda Borosilicate Glasses, J. Amer. Ceram. Soc., *24*, 123-130 (1941).

Irany, E. P., Borated Resins, Ind. Eng. Chem., *35*, 1290-1292 (1943).

Jaulmes, P. and Galhac, E. and Gontard, A., Volatility of Boric Acid. I—Aqueous Solutions. II—Dry Boric Acid and Superheated Steam. Bull. Soc. Chim., *4* (v) 139-148, 149-157 (1937), From Brit. Chem. Abs. A, 136 (1937).

Jenkel, E., On the Constitution of Glasses, Ztschr. Elektrochemie, *41*, 211-215 (1935). Remarks on the transformation regions of sodium and barium borate glasses.

Kalsing, H., Thomas, M., Wagner, M. and Enss, J., Experiments on the Replacement of Boric Oxide and Lead Oxide in Technical Glasses, Glastech. Ber., *18*, 210-213 (1940).

Keppeler, G., The Surface Tension of Glass, J. Soc. Glass, Techn., *21*, 53-60 (1937). In contrast to other properties, the surface tension of a soda-lime-silicate glass does not go through a maximum or minimum if increasing SiO_2 is replaced by B_2O_3. Increasing amounts of B_2O_3 lower the surface tension.

King, B. W. and Andrews, A. I., Solubility of Zirconia in Soda Borosilicate Glasses, J. Amer. Ceram. Soc., *24*, 367-372 (1941).

King, B. W. and Andrews, A. I., Viscosities of Glasses Na_2O-B_2O_3-SiO_2, J. Amer. Ceram. Soc. *23*, 232-235 (1940).

Klemm, A. and Berger, E., Investigation of the Expansion Behavior of Glasses in the Transition Region from the Rigid to the Viscous State. Glastechn. Ber., *5*, 405-417, (1927-28).

van Klooster, H. S., On the Behavior of Metaboric and Metaphosphoric Acids in the Melts of Their Alkali Salts, Z. anorgan. Chem., *69*, 122-134 (1910).

Kracek, F. C., Morey, G. W. and Merwin, H. E., The System H_2O-B_2O_3, Amer. Journ, Sci., *35*, A 143 (1938).

Leontjewa, A., Viscosity of Glasses in the System SiO_2-B_2O_3 and Na_2O-B_2O_3, Russ. Journ. Phys. Chem., *13*, 1020-25 (1939).

Lindemann, A. F. and Lindemann, F. A., X-ray Transmitting Glass, Ger. Pat. 223,654, Ztschr. f. Rontgenkunde *13*, 141 (1911).

Lux, H. and Rogler, E., Investigation of Fused Borates by Means of a

(*Continued on page* 654)

INVENTIONS AND INVENTORS

A Summary of Recently Issued Patents of Interest to the Glass Industry

Furnaces

Corning Melting and Casting Apparatus. Fig. 1. Patent No. 2,451,086. This patent was assigned to Corning Glass Works by John F. G. Hicks and Carl F. Henkel. It is a division of an application filed Dec. 5, 1941, which application is now abandoned. The invention is directed particularly to making optical glass but it may be employed in the manufacture of other kinds of glass. The patent claims to set forth a means for making a highly homogeneous glass which can be readily reproduced in different melts.

Optical glass made in the conventional manner requires the breaking up of refractory pots so as to recover a part of the glass in usable form. These inventors have found out how to make a melt and to recover 80 to 90 per cent of high optical quality. The apparatus by which this is accomplished is shown in section, in Fig. 1 where the numeral 11 indicates a furnace assembly mounted on a platform 12 of the frame 13. The frame 13 is carried by two circular tracks, one of which is shown at 15. These are tracks riding on wheels 16 so that the assembly may be rocked or inverted.

The furnace 11 includes a container 25 having compartments a and b, the container being recommended to be made of platinum and having an opening 27. This container is incased in a shell 29 of refractory material and the necessary means are provided to prevent the escape of heat. The container assembly is controlled as to its angular position, by a chain 41 which, in turn, is controlled by a switch panel arranged to rock the assembly, change the speed of movement, stop the apparatus at the desired times and, in fact, control all the rocking movements of the container.

After the glass batch is thoroughly fined and ready for pouring, it is all placed in one of the compartments where the bubbles (if any) are allowed to escape. Then the contents of the container are discharged onto a mold which moves so that there is no mixing of the glass deposited on it. In this way a superior quality of glass is secured and it can be reproduced as often as desired.

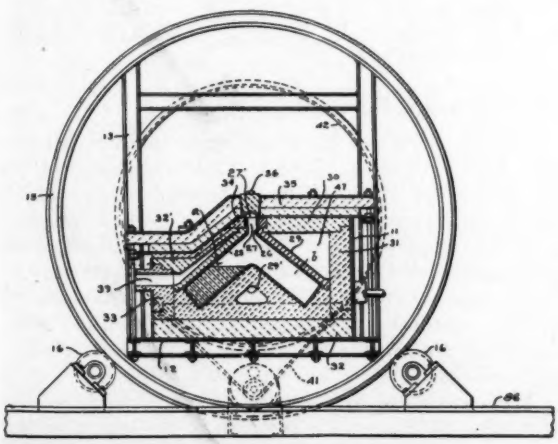

Fig. 1. Corning Melting and Casting Apparatus.

The following references are of record in the file of this patent: United States Patents: 305,376, Del Marmol, Sept. 16, 1884; 698,980, Lohme, Apr. 29, 1902; 708,113, Baldwin et al., Sept. 2, 1902; 708,782, Schwartz, Sept. 9, 1902; 749,403, Rousseau, Jan. 12, 1904; 770,832, Taylor, Sept. 27, 1904; 961,182, Vining, June 14, 1910; 1,059,634, Proeger, Apr. 22, 1913; 1,201,225, Gillett, Oct. 10, 1916; 1,827,469, Harrington, Oct. 13, 1931; 2,039,853, Stenhouse, May 5, 1936; 2,223,047, Ramseyer, Nov. 26, 1940; and 2,286,903, Dockerty, June 16, 1942.

Feeding and Forming

Machine for Drawing Glass Tubes. Fig. 2. Patent No. 2,450,115. This is an invention by Clarence P. Byrnes of Fort Lauderdale, Fla., who is well known in the glass trade as a patent lawyer who was in business for many years in Pittsburgh. The patent shows a machine for the upward drawing of a tube of glass which may have any desired cross sectional conture.

The figure shows a forehearth 2 projecting from a tank 3. The forehearth has a topstone 4 having a circular opening enclosed by a water cooled shield 5a. A floater ring 7 connects the shield and the surface of the molten glass. The mechanism cuts the circulation of air directly below the drawing mechanism and it is vertically adjustable by means of eyes 6 and 6a.

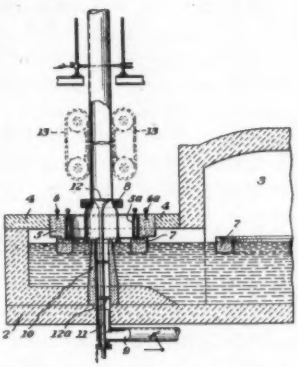

Fig. 2. Machine for Drawing Glass Tubes.

A cooled die ring 8 is mounted at an adjustable distance above the surface of the glass and the opening in this ring corresponds to the shape of the tube to be drawn. Air for expanding the tube being drawn comes from a pipe 9 leading to a nozzle 10 which extends slightly above the glass level. A stopper or valve 12 mounted on a stem 11 may be adjusted to regulate the air pressure in the tube behind drawn. It will be noted that the ring 8 cooperates with the valve 12 to control the air allowed to pass. The tube may be lifted by grippers 13 or by a lifter as shown in Byrnes Patent No. 1,425,746 dated Aug. 15, 1922. This patent also shows a severing means for cutting the tube into the desired lengths. The machine described gives a large increase in production and a better quality of ware than possible heretofore.

The following references are of record in the file of this patent: United States Patents: 702,015, Lubbers, June 10, 1902; 846,102, Frink, Mar. 5, 1907; 1,425,746, Byrnes, Aug. 15, 1922; 1,892,806, Pedersen, Jan. 3, 1933; 1,987,633, Pedersen, Jan. 15, 1935; 2,166,871, Luertzing, July 18, 1939; and 2,267,554, Despret, Dec. 23, 1941.

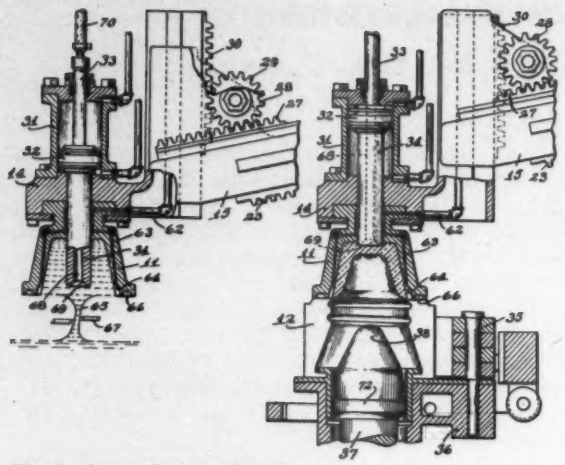

Fig. 3. Owens Suction Machine.

Owens Suction Machine. Fig. 3. Patent No. 2,450,995. Harold R. Schutz, the inventor, assigned this patent to Owens-Illinois Glass Company. The machine comprises a series of suction heads mounted on a continuously rotating turret. Each head as it approaches the pool of molten glass is projected radially and downwardly so that the mold contacts the surface of the glass while a charge is being drawn into the mold by suction. The general arrangement of the machine resembles the Westlake Machine more than the old Owens Machine.

Several steps in this operation are shown in the figure. At the left the suction mold 11 mounted on a head 14 has been projected by a ram 15 into contact with the surface of the pool of molten glass, a charge has been drawn into the mold and this charge is connected with the glass in the pool by a neck 65 which is about to be severed by shears 67.

A neck mold unit is associated with each head, this unit comprising a neck mold 12 and a press plunger 37 shown at the right of the figure. After the glass in the mold has been severed from that in the pool, the plunger 34 is moved upwardly while suction is applied through the channel 68, thus forming the mold charge into cup-like shape. After this, the neck mold 12 is closed about the bottom of the suction mold and the press plunger 37 is lifted to shape the finish in the neck ring and to give final form to the parison. Reference is made to a patent to Cramer, No. 1,693,069, for information as to the operation of the neck mold unit.

After the parison has been pressed by the lifting of the press plunger 37, the mold 11 is lifted and the neck ring and associated mechanism is inverted. A conventional blow mold is closed around the parison, the press plunger is lifted and the ware is blown in the usual way.

The above mentioned patent to Cramer gives further details as to the final blow and other minor features which may be employed.

The following references are of record in the file of this patent: United States Patents: 1,223,393, Kadow, Apr. 24, 1917; 1,693,069, Cramer, Nov. 27, 1928;1,764,-360, Soubier, June 17, 1930; 1,856,518, Soubier, May 3, 1932; 1,875,827, Soubier, Sept. 6, 1932; 1,904,985, Cramer, Apr. 18, 1933; 1,931,336, Van Ness, Oct. 17, 1933; 2,016,361, Cramer, Oct. 8, 1935; and 2,226,504, Rowe, Dec. 24, 1940.

Glass Wool and Fibers

Machine for Making Fine Glass Fibers. Fig. 4. Patent No. 2,450,363. This machine is the invention of Games Slayter and Ed Fletcher who assigned it to Owens-Corning Fiberglas Corporation. By the method proposed here, fibers as small as from four to ten hundred-thousandths of an inch in diameter may be made. Fibers as fine as this are useful in making sewing thread, inorganic paper, reinforcing plastics and for various other purposes.

As shown in the drawing, a glass feeder 10, which is preferably electrically heated, has orifices 11 from which the molten glass flows. This stream of glass is attenuated to form filaments 12 by means of blowers 13 and 14 which cause the molten glass to solidify and may also act to draw out the fibers to smaller diameter. The fibers thus formed are acted upon by a high temperature blast 21 which is directed preferably at about 90° to the path of travel of the fibers 12. The fibers are directed by the blast 21 against a conveyor 23 having a suction box 24 to assist in collecting the fibers into a mat 26.

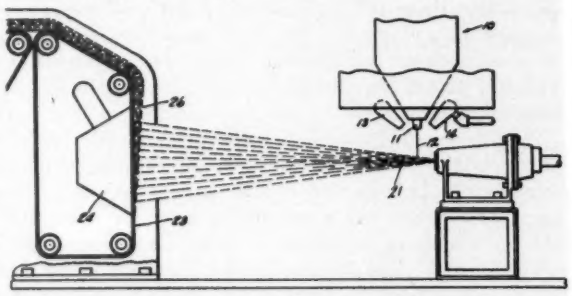

Fig. 4. Machine for Making Fine Glass Fibers.

The original fibers 12 are relatively large, about two to ten ten-thousandths of an inch in diameter. This diameter may be reduced to as little as four hundred-thousandths in the mat being formed. Adjustment of the temperatures, air pressures and direction of the blasts can be used to control the final diameter of the fibers.

The following references are of record in the file of this patent: United States Patents: 1,689,551, Hammond, Oct. 30, 1928; 2,126,411, Powell, Aug. 9, 1938; 2,133,-235, Slayter, Oct. 11, 1938; 2,172,153, McClure, Sept. 5, 1939; 2,175,225, Slayter, Oct. 10, 1939; and 2,272,-588, Simison, Feb. 10, 1942.

Miscellaneous Processes

Method of Making Multifocal Lenses for Eye Glasses. Fig. 5. Patent No. 2,447,068. This is an invention by the late James H. Hammon of Vincennes, Ind., and it relates to the manufacture of lenses of the trifocal type; that is, having provision for three ranges of vision as compared to the usual bifocal lens which takes care of two ranges of vision. The invention relates back to earlier patents by the same inventor, Nos. 2,006,638; 2,029,479; 2,029,479; 2,029,480; 2,065,132; 2,177,021; and 2,177,022.

The invention is of a very complicated nature and no less than 45 figures are required to explain it in the patent. The figure reproduced here shows the finished

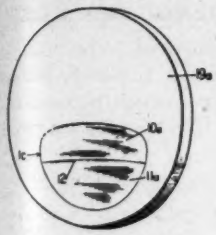

Fig. 5. Method of Making Multifocal Lenses for Eye Glasses.

lens blank where the portions of the lens 10a and 11a of the segment 1c are shown on the finished lens blank. It is practically impossible to abstract a patent of such complication and any one interested should make a study of the original patent.

The only references cited by the patent office in the file of this application were 2,033,573, Hancock, Mar. 10, 1936 and 2,388,687, Hammon, Nov. 13, 1945.

Device for Opening Ampuls. Fig. 6. Patent No. 2,447,988. This is an invention by Louis A. Pierson of Meriden, Conn. The invention relates to the opening of hermetically sealed glass containers having elongated necks provided for easy breakage. When such ampuls are opened by breaking by hand, there is always the possibility that foreign matter from the hands may get into the contents and the chance that fine broken glass may fall into the opened ampuls as well as cutting the hands of the operator. With this improved tool, the ampul may be easily scored along an even line where the break will occur without producing glass fragments which might get into the contents.

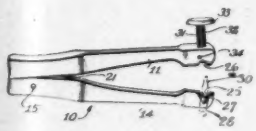

Fig. 6. Device for Opening Ampules.

Fig 6 shows this tool as comprising a cutter lever 11 and an anvil lever 14 pivoted together at 15 and held in open position by a spring 21. The ends of the levers are provided with angular recesses 25 and 26 which when the tool is closed, form a square having sides slightly greater than the diameter of the neck 27 of the ampul 28. A plunger 31 slides in the upper lever and is provided with a thumb button 33 and a spring 32 which holds the plunger retracted as far as permitted by the pin 34.

In the use of this tool, it should be held in the left hand with the thumb on the button 33 while the ampul is inserted in the jaws by the right hand. The jaws are then closed while the plunger is depressed so that its diamond-like point is brought against the neck while the ampul is being rotated. This makes a sharp and even scratch around the neck and the ampul may be easily opened without the dangers heretofore present.

The following references are of record in the file of this patent: United States Patents: 849,149, Lybeck, Apr. 2, 1907; 1,152,015, Fleming, Aug. 31, 1915; and 2,199,807, Moreira, May 7, 1940. Foreign Patents: 33,821, France, Aug. 21, 1928.

Glass Building Block. Fig. 7. Patent No. 2,449,458. This invention by Nathaniel C. Dryden of Poughkeepsie, N. Y., shows a glass block or brick quite different from the hollow blocks most frequently seen in commercial use. The new block is said to have numerous advantages over the more common form. It has the desired strength, insulates against heat and sound and can be used so that no finish is required either inside or out.

The figure shows one of these blocks having a center

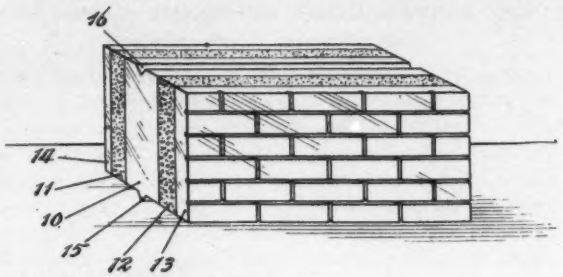

Fig. 7. Glass Building Block.

10 of solid glass and on each side a sheet 11 and 12 of cellular (or foam) glass. The outside of the block is formed by a sheet of solid glass 13 which may be decorated as shown to represent bricks, and the inside may or may not have a sheet or veneer 14 of solid glass. The top of each block has a groove 16 and the bottom a V-shaped rib 15 which interlock on adjacent blocks. It is apparent that the inside and outside of the blocks may have various colors and impressed designs. The patent gives directions for the use of these blocks around doors, windows and other parts of a building.

One example of the method of manufacturing these blocks requires the use of a mold having demountable walls which form five compartments corresponding to the five sections of the finished block. Each compartment is filled with the proper kind of molten glass and while the glass is still hot enough to fuse together, the intervening walls are removed. The aeration of the foam parts 11 and 12 can be done in the mold. After the block has hardened, the usual annealing process can be carried out.

The following references are of record in the file of this patent: United States Patents: 250,635, McLean, Dec. 6, 1881; 711,541, Standau, Oct. 21, 1902; 1,748,587, Smedley, Feb. 25, 1930; 1,794,678, Eastman, Mar. 3, 1931; 2,067,313, Caryell, Jan. 12, 1937; 2,152,190, Henderson, Mar. 28, 1939; 2,205,534, Lytle, June 25, 1940; 2,268,251, Haux, Dec. 30, 1941; and 2,310,432, Haux, Feb. 9, 1943.

Glass Bending Device. Fig. 8. Patent No. 2,450,297. John P. Pearse and William P. Bamford made this invention and assigned it to Libbey-Owens-Ford Glass Company. A sheet of flat glass is bent to the desired curvature without injury to the surface by shielding certain parts so as to give a time-temperature lag thus retarding the bending of the shielded area or keeping it flat.

The drawing shows a section through one form of the

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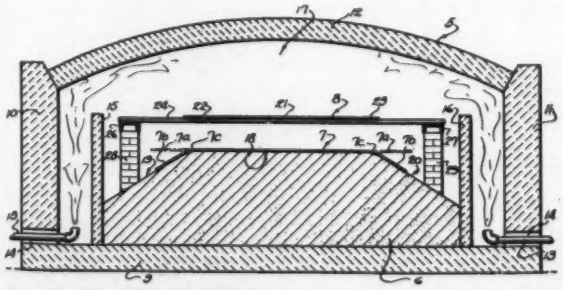
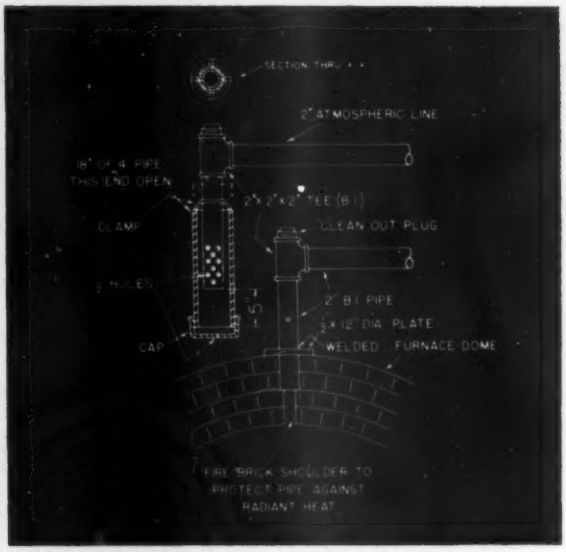


Fig. 8. Glass Bending Device.

THE INSTALLATION OF DRAFT GAGES IN INDUSTRIAL FURNACES*

Draft or pressure connection to an industrial furnace such as an open hearth, slab or skelp heating furnace, or glass melting furnace is generally made through the center of the roof of the furnace. This applies to recuperative as well as regenerative furnaces because the draft or pressure at this point bears the same relation to the draft and pressure conditions at all other points in the furnace. It is therefore the measurement of most value.



1. Insert a piece of standard 2-inch pipe part way through the roof in line with an opening in the refractory that passes through to the furnace, as shown in the drawing. The refractory between the furnace and the pipe protects the pipe from the intense heat usually existing at the furnace roof.

2. Fit a plug to the top of the pipe, and plug the top of the tee.

3. Use 2-inch pipe for the line to the instrument because draft and pressure values to be measured are generally less than 2 inches and the gage is usually mounted 50 feet or more from the furnace.

4. Since it is necessary to read the draft or pressure at the furnace roof very accurately (.005 inch of water is desirable), a differential gage is generally used. The atmosphere connection for the gage is made from a point directly over the furnace roof.

5. Run the pipe from the atmosphere connection side by side with the pressure line from the furnace to the gage, thus eliminating temperature errors.

6. Use a static tip (see drawing) on the end of the atmosphere line. Protect the tip from dirt and velocity effect by a length of 4-inch pipe held in place by welded support with top end open as shown.

*Reprinted from *Energy*, Vol. 10, No. 5, May-June 1948.

● Officials and sales representatives of E. F. Houghton & Co., Limited, of Canada, an affiliate of E. F. Houghton & Co., Philadelphia, recently attended the formal opening of the new Houghton plant in Toronto. Completed a short while ago, the plant is now operating at nearly full capacity.

TENTH CONFERENCE ON GLASS PROBLEMS

The Tenth Conference on Glass Problems, to be held at Columbus, Ohio, Thursday and Friday, December 2 and 3, 1948, will deal with problems of instrumentation, refractories and decorating of glass. The following program has been arranged for the meeting:

Instrumentation: "Principle of Automatic Control for the Glass Industry" by J. C. Peters, Leeds & Northrup Co., Philadelphia, Pa.; "Instrumentation of Glass Furnaces" by J. R. Green, Brown Instrument Company, Pittsburgh, Pa.; "Engineering Aspects of Automatic Control of Glass Manufacturing Equipment" by K. Gass, Amsler-Morton Company, Pittsburgh, Pa.; "Automatic Control from a Combustion Engineering Viewpoint" by R. J. McKinstry, Anchor Hocking Glass Co., Lancaster, Ohio; and "The Economic Value of Tank Instrumentation" by J. R. Hanson, Puerto Rico Glass Corporation, San Juan, Puerto Rico.

Refractories: "Bonded Refractories for Special Purposes" by R. W. Knauft, Chas. Taylor Sons Company, Cincinnati, Ohio; "Special Refractories for the Glass Industry" by W. F. Rochow, Harbison-Walker Refractories Co., Pittsburgh, Pa.; "Regenerator Materials for Glass Furnaces" by R. G. Abbey, General Refractories Co., Philadelphia, Pa.; and "Applications of Electro-cast Refractories in the Glass Industry" by A. A. Turner, Carborundum Company, Perth Amboy, N. J.

Decorating: "The Decorating of Fine Glass Ware" by C. J. Uhrmann, Imperial Glass Co., Bellaire, Ohio; and "The Applied Decoration of Glass Ware" by V. H. Remington, B. F. Drakenfeld & Co., Inc., Washington, Pa.

The Tenth Conference is the first presentation of the conference at Columbus under the cooperative efforts of the Departments of Ceramic Engineering of the University of Illinois and the Ohio State University. The 1949 conference will be held at Urbana, Illinois.

All inquiries concerning the Conference should be addressed to Dr. Henry H. Blau, Department of Ceramic Engineering, Ohio State University, Columbus 10, Ohio.

KNOX PRODUCES ONE-WAY CARBONATED BEVERAGE BOTTLE

The Denver Glass Bottle Company, a member of Knox Associates, is producing a one-way carbonated beverage container for the Cola Moca Company of Denver, Colorado. The bottle was designed by Knox Glass Associates, Inc., and is a short neck, crown finish, flint glass container, 8⅜" high, which requires no deposit. It is made at 18½ ounces glass weight and has a 25-ounce capacity.

The bottle is a private mold container featuring a blown in Royal Family Coat of Arms' trade mark. The particular flavor identification is achieved through the use of various colored crowns.

The Royal Family bottle is filled on fully automatic lines at 4½ to 5 volumes carbonation and has been considered a trouble-free container throughout the filling line operation.

● Amory Houghton, Chairman of the Board, Corning Glass Works, has been appointed a member of the Research and Policy Committee of the Committee for Economic Development. The Committee is responsible for statements on national policy.

Research Digest

Determination of Iron

The gravimetric determination of iron as the oxide after separation as the sulfide, although extremely accurate, is time-consuming and requires close attention to detail. In an effort to obtain a simple and rapid method of comparable accuracy, J. J. Diamond (*Journal of the American Ceramic Society*, Sept. 1948) has investigated the possibilities of the colorimetric σ-phenanthroline method.

As a result of this investigation, the following procedure is recommended: Weigh a 10-gm sample of sand into a platinum dish, add 25 ml. of 1:1 H_2SO_4 and approximately 50 ml. of HF solution, and place on a steam bath. Stir the mixture occasionally and add HF as needed until the sand has dissolved as completely as possible. Care should be taken to avoid loss of material by spattering. Evaporate the water and HF on the steam bath, add a few drops of concentrated HNO_3 to oxidize organic matter, and heat to SO_3 fumes on a hot plate or an air bath. Fume for a few minutes, cool, wash down the sides of the dish with water, and again evaporate the water and fume off SO_3 for a few minutes. Add water, heat to dissolve and precipitate, filter the solution through a retentive 9-cm. paper and wash the paper several times with hot water. Reserve the filtrate. Burn off the paper in a platinum crucible, fuse the residue with 1 to 2-gm. of Na_2CO_3, and dissolve the melt in 1:5 H_2SO_4. Filter through a retentive 9-cm. paper and wash several times with hot water. Combine the filtrates. Burn off the paper in a platinum crucible and fuse for a short time with the minimum amount of $K_2S_2O_7$. Dissolve the melt in hot water and add it to the combined filtrates. Cool the solution and adjust its volume to 250 ml. in a volumetric flash.

Pipette a 25 ml. aliquot*, equivalent to a 1-gm. sample, into a 100 ml. volumetric flash and add 10 ml. of a 10 per cent tartaric acid solution†. Add a drop of *p*-nitrophenol indicator‡ and concentrated NH_4OH until the indicator turns yellow. Add 1:1 HCl dropwise until the solution is barely acid to the indicator and add one drop in excess. Cool to room temperature. Then add about 2 ml. of a 10 per cent solution of NH_2OH:HCl§ and 10 ml. of 0.1 per cent σ-phenanthroline solution‖. Add water to make 100 ml. of solution.

After at least 10 minutes have elapsed, measure the percentage transmittance of the sample at a wave length of 505 mμ,¶ using as the reference solution a blank taken through the entire procedure. Read the Fe_2O_3 content from a calibration curve. A calibration curve is made by adding 1) known amounts of standard iron solution** to 100 ml. volumetric flasks and 2) reagents as previously described. Measure their percentage transmittancy, using a reagent blank as the reference solution.

*A maximum of 0.050 per cent of Fe_2O_3 can be determined directly by this method; if the sand contains more iron, use an appropriate smaller aliquot.

†Dissolve 10-gm. of tartaric acid in water and adjust to 100 ml.

‡Dissolve 1.0-gm. of *p*-nitrophenol in 75 ml. of 95 per cent ethyl alcohol and adjust to 100 ml. with water.

§Dissolve 10-gm. of $NH_2OH \cdot HCl$ in water and adjust to 100 ml.

‖Dissolve 1-gm. of σ-phenanthroline monohydrate in water and adjust to 1 liter.

¶Work done with a Coleman Universal spectrophotometer, powered by an 8-volt storage battery, and using 13 mm. square cuvettes.

**Dissolve 0.0350-gm. of National Bureau of Standards Standard Sample of Open-Hearth Iron, No. 55 a (99.83% of Fe), in 50 ml. of 1:1 HCl and dilute to 500 ml.; this is equivalent to 0.1 mg. of Fe_2O_3 per ml.

Knoop Hardness

The "hardness" of various materials has been studied by Peters and Knoop by a method which makes use of a ground diamond tool, impressed upon a polished glass surface by a known load. The tool has the shape of a blunt pyramid which produces an indentation in the surface of the material under test. The area of the indention can be measured. The load per unit area (kg./mm.^{2}) becomes a measure of the resistance of the material under test to indentation and this is one way of expressing "hardness."

In the January 1946 issue of the *A.S.T.M. Bulletin*, Vincent E. Lysaght discusses the Knoop Indenter as applied to the testing of non-metallic materials ranging from plastics to diamonds. The discussion, in the case of glass, is as follows: "The testing of glass presents a very different problem from plastic testing. In glass, we have a brittle material which would shatter under ordinary hardness testing penetrators and loads. A series of glasses was tested on the Tukon tester and Knoop indenter. In addition to the determination of the Knoop hardness number, as attempt was made to evaluate the

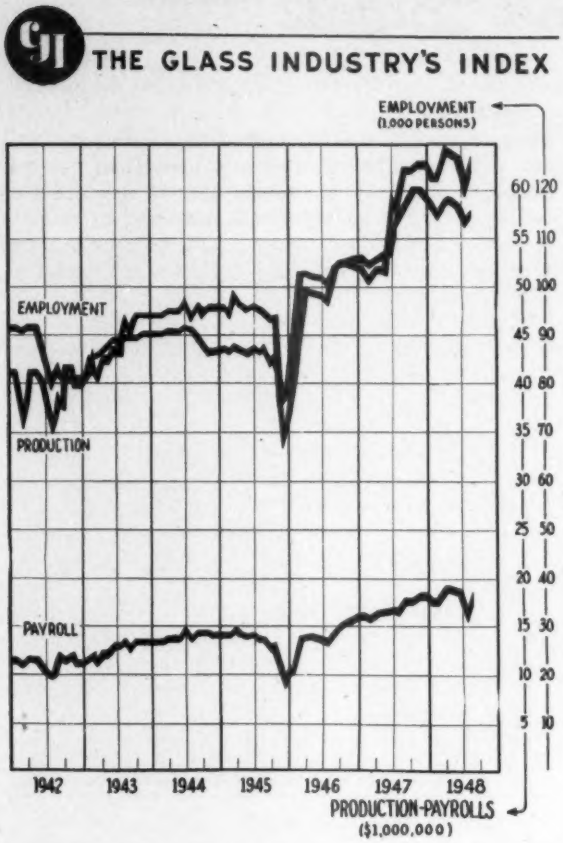
TABLE I

KNOOP NUMBER OF VARIOUS GASSES

Sample No.	Type of Glass	Knoop Number 500-g. Load
1	Soda-lime-silicate $\frac{3}{32}$ in.	538
2		531
3		544
4	Soda-lime-silicate $\frac{3}{16}$ in.	535
5		542
6		536
7	Soda-lime-silicate ¼ in.	518
8	Soda-lime-silicate ¼ in.	510
9	Heat treated	527
10	Soda-lime-silicate	528
11	Iron-soda-lime-silicate, with varying iron content	494
12		476
13		445
14		428
15	Soda-potash-lime-silicate	540
16	Barium silicate	546
17	Lead silicate with varying lead content	436
18		396
19		373
20	Phosphate	517

(*Continued on page* 648)

CURRENT STATISTICAL POSITION OF GLASS



August activity in the glass industry, as shown by the Production Index, rose about 12½ per cent to approximately $64,500,000 from the $57,500,000 reported during July. The low July figure may be attributed to the summer vacation shut-downs in many of the glass plants. During the month of August 1947, production was approximated at $62,500,000, which is about 3 per cent below August this year. Total estimated production for the January-August 1948 period has reached $502,300,000, as compared with $464,700,000 during the same period in 1947—a difference of about 8 per cent.

Employment and payrolls: During the month of August 1948, employment also increased from the 111,000 reported for July to 115,600 persons. This represents an increase of about 4 per cent. During August 1947, employment was 118,000, or 2 per cent above this year.

Glass manufacturers have paid out an estimated $18,000,000 during the month of August 1948 in payrolls. This represents more than a 12 per cent increase over the $16,000,000 paid out during July. Payrolls during August 1947 were approximately $17,500,000, which is about 2 per cent below August this year. Thus far in 1948, glass manufacturers have paid out an estimated payroll total of $131,750,000, as compared with $130,400,000 paid out during the corresponding period in 1947. This represents a difference of about 1 per cent.

Glass container production, based on figures released by the Bureau of Census, fell off slightly for the month of September 1948 to 8,711,910 gross. This is about 2 per cent below the 8,890,189 gross produced during August 1948. Production during the month of September 1947 was 9,389,852 gross, or 7 per cent above September this year. At the three-quarter mark of 1948, glass container production has reached a total of 75,578,014 gross, as compared with 89,263,746 gross produced at the close of the same period in 1947. This is a difference of 15 per cent.

Shipments for the month of September 1948 jumped slightly more than 20½ per cent to 10,442,430 gross. The August figure was 8,653,182 gross, which itself had

(*Continued on page* 640)

GLASS CONTAINER SHIPMENTS

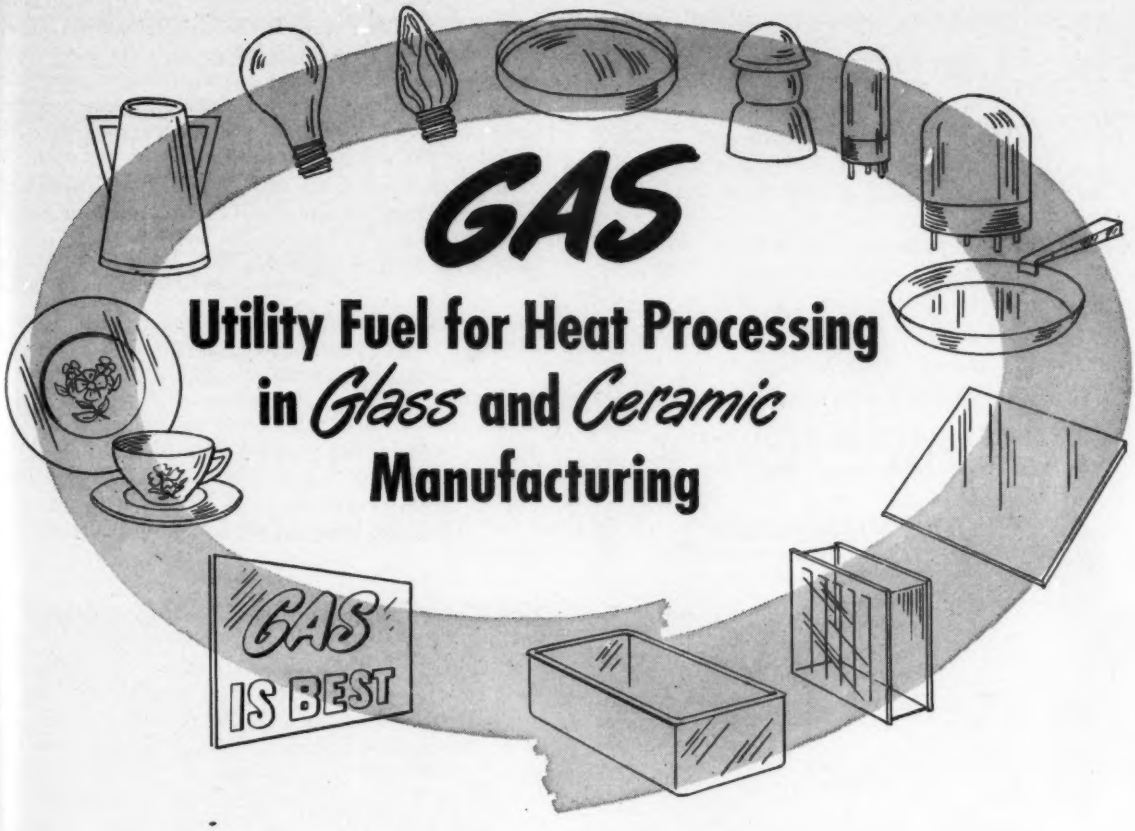
(All figures in Gross)

	September 1948
Narrow Neck Containers	
Foods	1,794,782
Medicinal & Health Supplies	1,379,642
Chemical, Household & Industrials	640,609
Beverages, Returnable	589,677
Beverages, Non-returnable	.....
Beer, Returnable	243,533
Beer, Non-returnable	435,738
Liquors	815,456
Wines	279,905
Toiletries & Cosmetics	519,742
Sub-total (Narrow)	6,699,084
Wide Mouth Containers	
Foods	2,405,813
Dairy Products	338,666
Home Canning	165,900
Medicinal & Health Supplies	267,793
Chemical, Household & Industrials	101,673
Toiletries & Cosmetics	119,714
Packers' Tumblers	136,094
Sub-total (Wide)	3,535,653
Total Domestic	10,234,737
Export Shipments	207,693
Total Shipments	10,442,430

GLASS CONTAINER PRODUCTION AND INVENTORY

(All figures in Gross)

		Production September 1948	*Stocks September* 1948
Foods; Medicinal & Health Supplies; Chemicals, Household, Industrials; Toiletries and Cosmetics	Narrow Neck	3,399,499	2,502,150
	Wide Mouth	2,464,322	1,735,317
Dairy Products		313,294	196,642
Home Canning		155,216	446,574
Beverages, Returnable		553,498	682,062
Beverages, Non-returnable		.....	.....
Beer, Returnable		166,964	712,585
Beer, Non-returnable		364,997	271,357
Liquors		882,308	418,080
Wines		269,622	193,162
Packers' Tumblers		142,190	88,543
Total		8,711,910	7,246,472



PRODUCT VARIETY expands constantly in the ceramic and glass industry and with every development heat processing requirements become more complex, production engineers more exacting.

Because GAS fulfills every demand for an all-'round fuel the manufacturers of modern Gas Equipment have worked side-by-side with ceramic and glass technicians to perfect the processes, controls, and equipment for maximum production.

The success of this joint effort is evident in the wide range of applications where *the productive flames of GAS* perform the heat processing functions in glass, ceramic, and related manufacturing. These applications include

- Annealing
- Drying
- Decorating
- Melting
- Stress Relieving
- Frit Smelting
- Glost Firing
- Polymerizing

The tasks for GAS are as widely varied as the products of the ceramic and glass industry. And, the flexibility, controllability, economy, cleanliness of GAS make it the real utility fuel for all heat processing. You'll find it worthwhile to investigate the advantages of modern Gas Equipment.

AMERICAN GAS ASSOCIATION

420 LEXINGTON AVENUE **NEW YORK 17, N. Y.**

PREMIUM PERFORMANCE
Without Premium Price

CRYSTALITE (mullite-bonded mullite) feeder parts now at a new lower price, offer a new 3-way cut into rising glass production costs.

- New lower price
- Same high crystaline bond for longer life
- Same close tolerance dimension accuracy

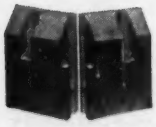
Specify **REMMEY CRYSTALITE,** the premium performance mullite . . . reduce costs 3 ways!

BONUS-BUILDING SPOUTS
Long-lived, firm closure at tube seat . . . close-tolerance machined for uniformly accurate location in feeder.

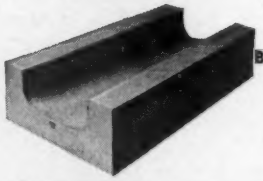
BONUS-BUILDING TUBES
High refractoriness and erosion resistance assure enduring firm closure at tube seat . . . and thorough agitation.

BONUS-BUILDING PLUNGERS
Retain shape longer for continued, more accurate control of glass gob.

BONUS-BUILDING ORIFICE RINGS—Retain shape and size for longer runs without costly replacement shutdowns.



BONUS-BUILDING BURNER BLOCK—Accuracy of dimension for quick, hairline matching to burners.



BONUS-BUILDING CHANNELS
Uniformity, accuracy, and structural quality combine for longer productive life.

REMMEY
Dependable Refractories
RICHARD C. REMMEY SON CO.
Philadelphia 37 • Pennsylvania

been a 10 per cent jump from July. Shipments during September 1947 were 9,159,716 gross, or 14 per cent below September 1948. Total shipments for the first nine months of 1948 have reached 75,737,770 gross, as compared with 85,157,913 gross shipped during the same period in 1947—a difference of about 11 per cent.

Stocks on hand at the close of September 1948 were 7,246,472 gross, as compared with 8,871,193 gross on hand at the close of August 1948 and 7,477,653 gross on hand at the close of September 1947.

Plate glass production for September 1948, according to the Hughes Statistical Bureau, dropped 15 per cent to 20,774,233 sq. ft. from the 24,475,403 sq. ft. produced during August. Production of plate glass during September 1947 was 20,648,053 sq. ft., which is only slightly less than for September this year. Plate glass production thus far in 1948 has reached a total of 198,421,856 sq. ft., as compared with 190,188,262 sq. ft. produced during the same period in 1947—a difference of 4 per cent.

Automatic tumbler production dropped 1 per cent for the month of September 1948 and was reported to be 4,573,834 dozens. The August figure was 4,618,317 dozens. Production during September 1947 was 4,688,486 dozens. Shipments for September 1948 rose close to 6½ per cent to reach a figure of 4,976,398 dozens. The previous month's figure was 4,676,099 dozens. Shipments during September 1947 were 5,993,701 dozens. Stocks on hand at the close of September 1948 were 6,986,414 dozens, as compared with 7,396,999 dozens on hand at the close of August and 7,940,031 dozens at the close of September 1947.

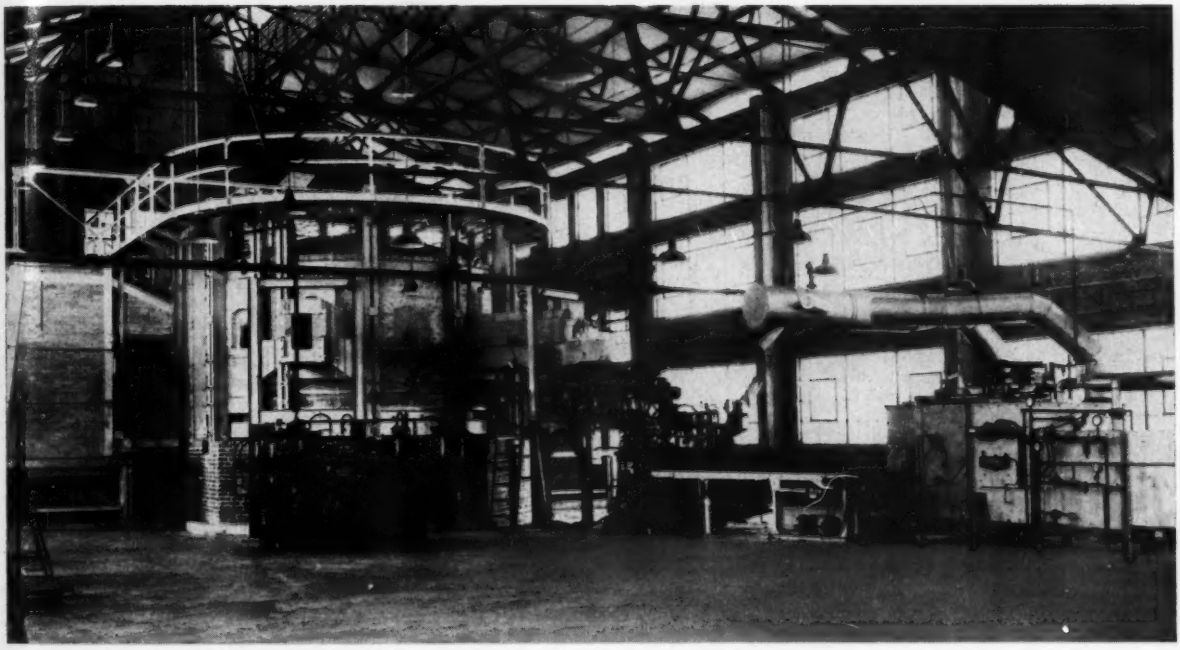
Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware for the month of September 1948 rose more than 11 per cent to a figure of 3,397,097 dozens. This is an increase over the 3,052,145 dozens sold during the previous month. During September 1947, sales were 3,483,287 dozens. At the close of the 12-month period ending September 1948, manufacturers' sales had reached a total of 42,844,396 dozens, as compared with 40,955,851 dozens sold at the close of the corresponding period in 1947.

Because of lateness, one company's figures are not included in the figures for automatic tumbler production and table, kitchen and household glassware. However, the totals for this company have been estimated for the compilation of the above figures and if you follow this department regularly, you will note that the figures are adjusted in the following issue when such an instance as this arises.

• Folding glass, to eliminate the narrow rear vision strip formerly necessary in convertible automobile top construction, has been developed at Pittsburgh Plate Glass Company. Formed of a special plate glass-plastic sandwich, the glass folds like an accordian on a ¾ inch plastic joint connection when the top is lowered.

DESIGN
ERECTION
OPERATION

Another example where unit responsibility pays dividends



AMCO Installation During Construction Period . . .

AMSLER MORTON
CORPORATION
Chamber of Commerce Bldg., Pittsburgh 19, Pa., U.S.A.

A.C.S. SECTION MEETINGS

The Pittsburgh Section of the American Ceramic Society opened its 1948-1949 season with a golf outing. While several groups were playing golf, others took a trip either through the New Castle Refractories Company, Shenango Pottery Company, Universal Sanitary Manufacturing Company or American Can Company. This was followed by dinner at the club house. The regular October meeting offered the opportunity for members to tour the new facilities of the Fisher Scientific Company. At the regular business meeting, it was announced that 295 members have at present paid up their dues for 1948-1949. Mr. John W. Whittemore, President of the American Ceramic Society, was speaker of the evening.

The first Fall meeting of the Trenton Section included a business meeting which was followed by a demonstration of induction and dielectric heating equipment manufactured by the Scientific Electric Company. John Sedlacsik, President of the company, and his Chief Engineer, Mr. McGonnigle, described some successful applications of their equipment in industry and demonstrated potential ceramic applications.

The Southern Ohio Section of A.C.S. opened its 1948-1949 season with a dinner meeting at which Hobart Kraner, Vice President of the Society, was the evening's guest speaker and whose subject was "Patents".

The first Fall meeting of the Northern Ohio Section presented H. M. Faust of the New York Coal Sales Company as speaker of the evening. His subject was "Coal, Its Availability and Reserves".

MICHIGAN ALKALI DIVISION HOLDS ANNUAL SALES MEETING

The annual general sales meeting of the Michigan Alkali Division of Wyandotte Chemicals Corporation was recently held. The meeting began with a visit to the plants in Wyandotte, Michigan, to view exhibits and new facilities, and was then followed by a two-day round-table discussion at St. Clair Inn.

During the opening session which was devoted to inspecting exhibits prepared by the company's Research Department, particular emphasis was given to new equipment and techniques developed by the department.

During the round-table discussion, question-and-answer periods were conducted by heads of research, engineering, public business, development and accounting. Thereafter round-table discussions were carried on by Melvin Clark, in charge of soda ash, caustic and bicarb sales; by Howard Roderick, who handles the sale of organic chemicals, chlorine and calcium carbonate; and by L. D. Dodson, responsible for calcium chloride sales. Closing discussions were conducted by C. S. Johnson and Dr. Paul Burchfield, director and assistant director of Technical Service, Michigan Alkali Division.

DU PONT STOCK REPORT

E. I. du Pont de Nemours & Co., Inc., was owned by 94,557 different stockholders as of September 30, an increase of 313 over the number of holders recorded as of the end of June 1948 and an increase of 3,573 holders over the corresponding period in 1947.

There were 76,980 holders of common stock and 23,674 holders of preferred stock as the third quarter of 1948 ended.

E. R. BALLING REELECTED A DIRECTOR OF CONTROLLERS INSTITUTE

Edwin E. Balling, Jr., Vice President and Treasurer of the Latchford-Marble Glass Company has been reelected a Director of the Controllers Institute of America. This action took place at the organization's 17th Annual Meeting held recently in New York City.

Mr. Balling, who has been a member of the Institute since 1938, was first chosen to the Board a year ago. He was President of the organization's Los Angeles Control in 1943-44.

CARBORUNDUM PURCHASES NEW PLANT

To meet the increasing demand for its "Monofrax" refractories, The Carborundum Company has recently expanded its production capacity through the purchase of a plant near Falconer, New York. The main building provides 50,000 square feet of manufacturing space and will be devoted solely to the production of Monofrax, which is a fused refractory material.

Actual production is scheduled to begin approximately January 1, 1949 and will augment present output by several hundred tons monthly. The plant site at Falconer is of sufficient size to accommodate future expansion. It is serviced by the main line of the Erie Railroad and a spur of the New York Central.

L-O-F PRODUCTION NOTES

Production of "golden" plate glass has been resumed by Libbey-Owens-Ford Glass Company, it has been announced.

The special glass excludes more than 99 per cent of the ultraviolet rays in sunshine without noticeably impairing vision or greatly reducing light transmission. One of the most recent uses has been in television protective screens to filter out ultraviolet light.

The "golden" plate glass is quarter-inch in thickness and stock sizes will run to a maximum of 100 by 150 inches. On special order, sizes up to 110 by 200 inches may be manufactured.

A new large size of transparent mirror, 30 by 60 inches, of polished plate glass $^{13}/_{64}$ of an inch in thickness is also now being produced by L-O-F. The company is continuing to make the 12 by 40-inch, 20 by 40-inch and 30 by 40-inch stock sizes of polished plate glass $^{1}/_{8}$ of an inch thick.

CHANGE OF OFFICERS AT GILLINDER BROTHERS

Gillinder Brothers, Inc., has announced the following change of officers. Elected President is J. Fletcher Gillinder, who has been associated with the company since 1922. He graduated from the University of Pennsylvania as Chemical Engineer and has been Production Manager since 1931.

William T. Gillinder has been elected Vice President after being closely associated with the sales work of the company for many years. He graduated from the University of Pennsylvania Business Administration and has been with the company since 1923.

Both of the newly elected officers are sons of Edwin Bennet Gillinder, one of the founders of the present business.

DEFIES FLUXING ACTION!

Your tank's stoutest defense against the attack of molten glass is FLUXTITE Tank Blocks. From raw material to final finishing, all our skill and long experience is concentrated on packing greater stamina into FLUXTITE:

- Blended mainly from genuine Missouri clays, to our exclusive formula perfected by years of laboratory and field research.
- Bond Clays used are weathered and treated for maximum purity, plasticity and strength.
- Burned long at peak temperatures to insure soaking heat, uniformity of burn.
- Precision-ground for quick, economical laying.
- **RESULT:** A REFRACTORY MORE THAN EQUAL TO ITS TASK!

FOR MAXIMUM ECONOMY AND PRODUCT QUALITY SPECIFY LACLEDE-CHRISTY

MIX 89 — GLASS HOUSE SPECIALS — FIREBRICK AND CEMENTS — BUCKEYE BRAND OPEN AND COVERED POTS

One dependable source for EVERY refractory you need

LACLEDE-CHRISTY FOUNDED 1844 ST LOUIS, U.S.A.

LACLEDE-CHRISTY COMPANY

Ambassador Bldg., St. Louis 1, Missouri

The World's Largest Producers of Glass House Refractories.

NEW EQUIPMENT AND SUPPLIES

BAUSCH & LOMB DEVELOPS NEW SERIES OF 15 MICROSCOPES

Bausch & Lomb Optical Company, Rochester 2, New York, has announced the production of a new series of wide-field microscopes that provide a greater field of observation than ever before attained.

Consisting of 15 basic models that can be interchanged into 58 different combinations for medical research, industrial and educational purposes, the microscopes' optical systems are completely sealed to prevent dust from reaching the interior.

Dissecting microscopes are now available with an extra large stage and base, while an elaborate instrument is offered to industry for use in surface examination. With the latter, a circular area of five feet in diameter may be inspected.

All eyepieces and objectives are of new design. The objectives minimize image deterioration at the edge of the field of view, while the eyepieces provide a higher eye point for greater comfort and prevent interference with glasses should the user wear spectacles. A dustproof, sliding nosepiece on three-objective models offers a rapid, convenient means of interchanging objectives and insures viewing the subject with but one objective at a time.

Four positions are provided for a new illuminator and fluorescent lamp to enable the microscopist to arrange his lighting as a photographer would suit his subject. The microscopes are equipped with diffusing discs of black and white that provide background contrast.

NEW PORTABLE ELECTRIC DISC GRINDER

Porter-Cable Machine Company, 1714 N. Salina Street, Syracuse 6, New York, has announced a 5-in-1 portable electric tool, the D-6, which grinds, polishes, cuts, drills, buffs in glass, wood, metal, ceramics, plastics, etc.

The basic unit is a 6″ disc grinder with attachments to convert it into a polisher, sander, drill, paint mixer and stone and metal cut-off tool. A drill chuck takes a ¼″ shank for a wide variety of standard attachments.

A stiff 7″ disc, infused with silicon carbide grit is used edgewise to cut stone, steel and other hard compositions. Resilient abrasive discs may be used for sanding and polishing.

NEW THICKNESS DETECTOR

Branson Instruments, Inc., Joe's Hill Road, Danbury, Conn., has announced a new model of the "Audigage" Thickness Detector.

The improved Model FMSS-5 Audigage thickness detector is used for non-destructive thickness measurement of glass, steel, copper, unfilled plastics and other materials, *from one side.*

Model FMSS-5 features instrument indications; adjustable frequency modulation; facilitates the measurement of seriously corroded equipment; special permeability tuning unit for increased sensitivity over the whole frequency range; increased frequency range for measurement of steel down to 1/16″. Special ranges can be provided for thinner materials.

FAIRBANKS, MORSE NEW LINE OF MOTORGEARS

Fairbanks, Morse & Company, Chicago, Illinois, have announced that their axial air gap motor is now available as a motor reducer.

The outstanding features of the axial air gap motor are space and weight reduction, the motor being less than half the size of the conventional type motor and weighing less by approximately one-third, yet retaining all the necessary characteristics of sturdiness and power requirements.

Available in ratings from ¾ to 10 HP, these units are symmetrical in design with no separate right-hand or left-hand assemblies. The motor may also be removed from the gear housing and run separately. The new motorgear employs two ratios of single helical gears with hardened and accurately shaved teeth arranged in simple gear trains.

Another feature is that the motor and gear shafts are parallel with the centerline of the motor, coinciding with the centerline of the low speed shaft. The motor shaft rotates on ball bearings, while the gear shafts are mounted on tapered roller bearings.

The new motorgear is suitable for horizontal mounting, preferably on a level floor, but provisions can be made for wall, ceiling or angle mounting, provided the shafts remain horizontal.

NEW DEAD-WEIGHT THICKNESS CALIPER

E. J. Cady & Company, 134 N. La Salle Street, Chicago 2, Illinois, has announced the new Cady exact micrometer caliper. The instrument calipers thicknesses of sheet materials or other articles up to ½″. It provides thickness measurement for glass, steel, aluminum, plastics, or any sheet stocks with thicknesses within its range of operation.

The dead-weight principle employs devices to maintain uniform measuring pressure at all times, at any point of anvil travel, whether the article measured is thick or thin.

The instrument is provided with zero adjusting devices, accessible from outside the frame, permitting the indicator to be set at exact zero on the dial. Internally, the mechanism is designed to prevent an accident change of this zero adjustment and maintain perfect alignment of working parts.

CATALOGUES RECEIVED

The Brown Instrument Company, Philadelphia 44, Pa., has issued a new 31 page catalogue, No. 15-13, on ElectroniK Potentiometers.

The booklet has many schematic diagrams, photographs and dimensional drawings illustrating the constructional features and operating principles of the instruments presented.

Among the instruments and systems included in Catalogue No. 15-13 are the ElectroniK strip chart electric control potentiometers, strip chart and circular chart recorders, precision indicators, strip chart and circular chart controllers, indicating controllers, pyrometric switches, thermocouple and radiamatic assemblies and the "continuous balance" principle.

Another feature of the new Brown catalogue is the presentation of illustrative tables of various control forms, typical control systems, style selection tables and other data that is helpful in the selection of proper instrumentation.

The Harshaw Chemical Company, Cleveland 6, Ohio, has issued a booklet containing the prices of the ceramic materials available through the company, together with illustrations and text matter, which make it an attractive presentation.

Several aerial views of the various plants follow the introduction, which, in turn, are followed with several close-ups of some phases of operation in ceramics production.

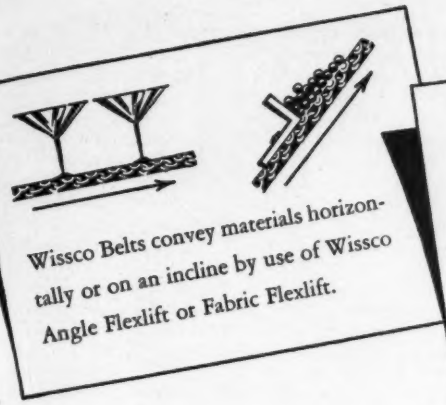
Price lists follow covering glaze stains, underglaze colors, colored glazes, overglaze colors, glass enamels, porcelain enamels, antimony oxide, etc.

E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa., has released a new folder, "Hot Spot" Lubrication, which has been prepared for glass and ceramic plants.

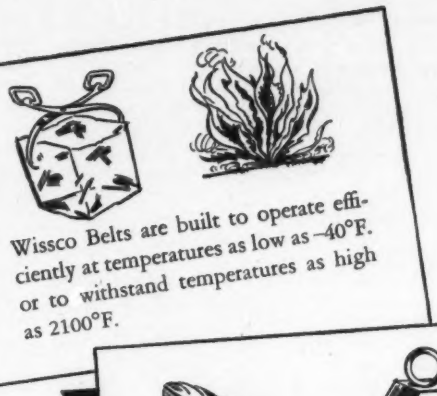
The pamphlet offers examples of lubrication difficulties met in these industries and suggests how to overcome the problems.

The remainder of the folder is devoted to the products offered by Houghton to the glass and ceramic industries. High temperature lubricants, glass mold aids, porcelain mold oil, rust removers for cleaning glass molds, automatic conveyor lubricants and greases for moderately high temperature applications are discussed.

Wheelco Instruments Company, 847 W. Harrison Street, Chicago, Illinois, has issued a new bulletin, "Electronic Controls," containing a listing of their standard instrument models.



Wissco Belts convey materials horizontally or on an incline by use of Wissco Angle Flexlift or Fabric Flexlift.



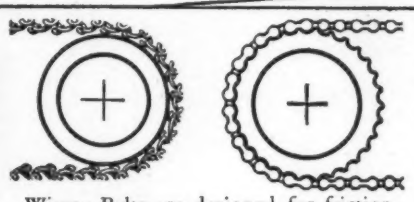
Wissco Belts are built to operate efficiently at temperatures as low as –40°F. or to withstand temperatures as high as 2100°F.

Whether your product is light or heavy, large or small, Wickwire can custom-engineer a belt to carry it safely and efficiently.

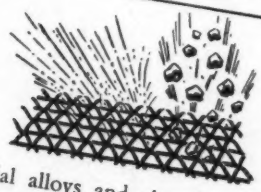
WISSCO BELTS' ADAPTABILITY

ANSWERS INNUMERABLE PROCESSING PROBLEMS

FIFTY YEARS of pioneering in belt development and design have provided the know-how for solving difficult problems—for custom-engineering Wissco Belts with the stamina and built-in toughness that insure new highs in production, new lows in cost. Why not avail yourself of the services of our belt engineers. There is no obligation—and it may provide the cost-cutting answer to rising production costs.



Wissco Belts are designed for friction drive installations or combined with several types of chain edge constructions for use on positive drive equipment.



Special alloys and chemical resistant metals are used in making Wissco Belts that must withstand corrosion, abrasion and other destructive forces.

To meet a wide variety of needs, Wissco Belts are available in a number of woven wire constructions and in plate and channel type constructions.

Let us send you our illustrated catalog showing types and advantages of numerous conveyor belt constructions. Write to our nearest office.

WISSCO METAL CONVEYOR BELTS

A PRODUCT OF WICKWIRE SPENCER STEEL DIVISION OF THE COLORADO FUEL AND IRON CORPORATION

CF&I

Belt Sales Office and Plant—56 Sterling St., Clinton, Mass. • *Executive Office*—500 Fifth Avenue, New York 18, N. Y.

Sales Offices—Boston, Buffalo, Chattanooga, Chicago, Denver, New York • *Pacific Coast Subsidiary*—The California Wire Cloth Corp., Oakland 6, Cal.

(*Continued from page* 622)

roller bearings, one of which is covered by a rubber sleeve.

For actual use, the instrument was set up in such a manner that only a few per cent breakage resulted when lots of tubing which were free from surface cracks were tested at a calculated maximum fiber stress of 10,600 pounds per square inch. Under these conditions, a mild case of "brittleness" would be indicated by an increase in breakage from 5 per cent to 10 or 15 per cent. An epidemic would be declared when the breakage reached 50 per cent, and a severe case of "brittleness" would be indicated by a breakage of 100 per cent. This method of testing makes it possible to observe more than one break per stick and very severe cases of "brittleness" are indicated by multiple breaks per stick.

When comparing various lots of tubing, the Factor of Merit to be assigned to a particular lot can be based on the percentage of broken sticks provided the breakage is less than 100 per cent. On this basis, a 5 per cent breakage results in a Factor of Merit of 95. In the case of multitple breaks per stick, the Factor of Merit may be based on the number of inches or feet of tubing tested.

Coloration of Glass by Gold, Silver and Copper. *By S. D. Stookey, Corning Glass Works, Corning, New York.*

Metal-colored glasses, such as gold, ruby, copper ruby and silver yellow, have been known for years, but the published information on the subject indicated a lack of agreement as to the states through which the metal passes during the preparation and heat treatment of the glass. A review of the literature indicated that there was no hypothesis which completely explains the coloring mechanism and also that there was none which is free from question on the basis of independent evidence. Early experiments in the Corning laboratory produced evidence that contrary to published statements, conditions of oxidation and reduction actually have an important influence on development of ruby color in gold-containing glasses. These experiments led to the belief that gold dissolves in an oxidized state and is subsequently reduced to free metal. Recent work on photosensitive glasses has contributed new evidence on the subject.

The significant results of the composition explorations (silicate glasses) are briefly summarized below:

Gold-Ruby Composition—Essential batch ingredients are a gold compound, oxidizing agents such as nitrates, and one or more compounds of polyvalent elements such as Sn, Sb, Bi, As, Pb, Fe, Se or Te. Se and Te compounds are the most effective, inducing ruby coloration in some glasses where other polyvalent compounds fail. Gold content of the finished glass is from 0.01 per cent to 0.1 per cent. High alkali glasses develop color more readily than low. Other things being equal, lead-base glass is more conductive to ruby formation than other glasses.

Copper-Ruby Compositions—Essential batch ingredients, besides copper compounds, include a mild reducing agent and one or more of the above-mentioned polyvalent compounds. Strong oxidation forms stable blue cupric ions which cannot be reduced to the metallic state by heat treatment. Strong reduction precipitates metallic copper during melting to form a brown cloudy glass. An intermediate state of reduction results in a nearly colorless glass which, on reheating, develops a good ruby color. If polyvalent compounds are not present, the resultant glass is either blue or a cloudy amber, depending on the state of oxidation.

Silver-Yellow Composition—The silver glasses produce clear yellow or amber color under conditions similar to those employed with gold rubies. Reducing agents or an excess of silver compound cause precipitation of silver at high temperatures to form cloudy amber glasses. The silver content required is about ten times that of gold.

Two factors appear to control the behavior of these glasses when heat treated. These are metal concentration in the batch and the state of oxidation of the melt. High metal concentrations and reducing conditions tended to precipitate metal while low concentrations and oxidizing conditions tended to prevent precipitation. Polyvalent ions, together with nitrates, permitted the glass to remain colorless at melting temperature and strike on cooling or reheating. Strong reducing agents invariably precipitated all of the metal compound as reduced metal. The glasses which contained dissolved metal compounds but did not strike on reheating were those in which the metal remained in an oxidized state throughout the melting and reheating cycle. In glasses containing a polyvalent compound and a relatively low concentration of metal, it was found to be possible to warm in a good ruby (Au or Cu) or yellow (Ag) color at one temperature and to cause it to disappear at a somewhat higher temperature. With all these glasses, reduced metal can be precipitated from the melt at still higher temperatures by introducing reducing agents.

From this experimental evidence, it is concluded that the coloring particles in these glasses are not compounds of the metal but are actually the metal itself, and that the metal exists in an oxidized state in the molten glass. These metal ions then become reduced at intermediate temperatures as the glass is cooled or reheated. The presence of polyvalent compounds is responsible for this reduction as such ions are, in general, stable in their lower states of valence at high temperature and in their higher states of valence at low temperature thereby become reducing agents as the glass cools.

Poisson Series in the Glass Industry and Elsewhere. *By F. W. Preston, Preston Laboratories, Butler, Pa.*

The lecturer began by asking a question in mental arithmetic, concerning the random distribution of birthdays, of a few hundred people, throughout the year, or the distribution of "stones" in bottles, assuming them to be random. When no one volunteered the answer, Dean Scholes, Dr. Tooley, Mr. Parikh of Calcutta and Mr. Charles Pearce, Secretary of the American Ceramic Society, were called to the stage, and given a number of "stones" (glass marbles) to drop at random into "bottles" (test tubes) arranged on the rim of a rotating platform. Dr. Ghering acted as master of ceremonies, supplying the marbles at irregular intervals, and Mr. McCormick counted out the result, which was shown to be a Poisson distribution.

The derivation of the series by theory, the limits of its applicability, its application to analyzing the behavior of a glass tank and other applications were illustrated.

An Improved Apparatus for the Determination of Liquidus Temperature and Rate of Crystal Growth in Glass. *By Oscar H. Grauer and Edgar H. Hamilton, National Bureau of Standards, Washington, D. C.*

The apparatus consists of a platinum-rhodium channel-shaped strip that contains hollow cells at regularly spaced intervals. Small glass fragments are loaded into the cells and the whole is immersed in a tubular gradient furnace. After an appropriate time interval, depending upon the composition of the glass, the strip is rapidly removed and air-quenched. Examination is made of the contents of the cells with the petrographic microscope, using transmitted light. The last cell in which crystals appear locates the position in the gradient corresponding to the liquidus temperature.

This method was developed to overcome errors that occurred when using the boat gradient method, due to the flow of the more fluid glasses when removing the boat from the furnace. In addition, the new method permits equilibrium and quenching to take place more rapidly, due to the small mass of the sample which is almost completely surrounded by the platinum-rhodium wall of the cell.

A comparison of the results obtained with this and the classical quench method showed an average deviation of 3.6°C. Data obtained on a rate of crystal growth in the various cells yield the familiar hump-shaped curve for a plot of temperature vs. crystal growth. Several proposed equations for this curve are discussed.

Applications for the apparatus are discussed both in the field of new glass composition investigation and in the manufacturing processes.

Burners for Lamp Working. *By H. K. Richardson, Westinghouse Lamp Division, Bloomfield, N. J.*

The burners required by high speed glass forming ma-

(*Continued on page* 650)

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RESEARCH DIGEST . . .

(*Continued from page* 637)

brittleness of the glass by increasing the load until fracture occurred around the impressions. Table I gives the Knoop number for the various glasses as determines under a load of 500 g. Each value reported is the average of five tests and samples Nos. 1, 2 and 3, samples Nos. 4, 5 and 6, and samples Nos. 8 and 9, respectively, represent different samples of the same material.

"It will be noted that there is good agreement in Knoop numbers on these materials, and, in fact, good agreement in all samples of soda-lime-silicate glass when tested under this load, except sample No. 8 which is definitely softer. (This same effect was not noticed in sample No. 9.)

"Particular attention is called to the decreasing Knoop number on samples Nos. 11 to 14 as the iron content is varied and samples Nos. 17 to 19 as the lead content is varied.

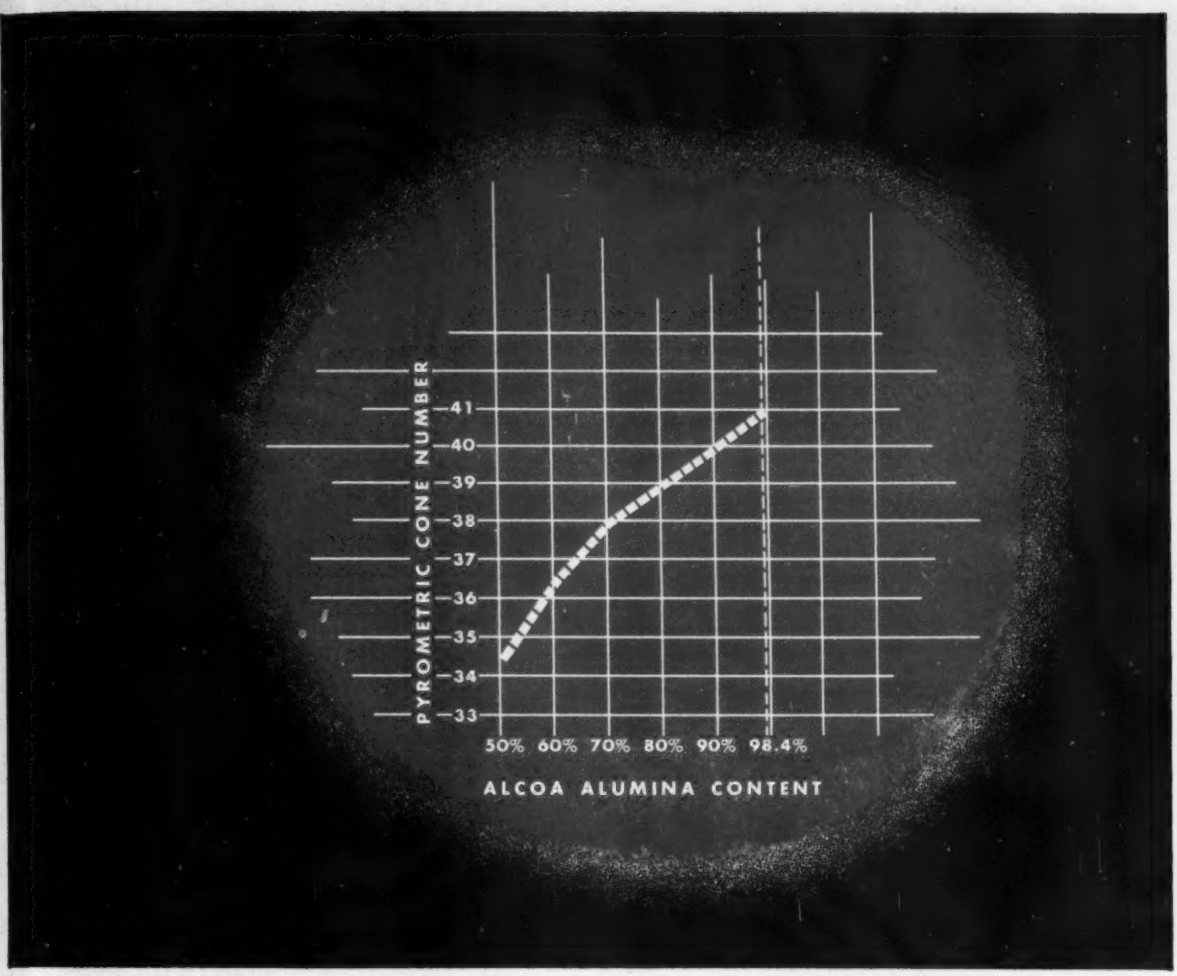
"The hardest sample, No. 16, was subjected to tests with loads increasing from 100 g. and it was found to fracture slightly with a load of 200 g. On the other hand, the softest sample, No. 10, withstood a load of 1400 g. before fracture occurred. This test was not entirely conclusive as an occasional test on sample No. 16 could be made with a load of 1000 g. without fracture.

TABLE II

KNOOP HARDNESS OF MOHS MINERALS AND ABRASIVE MATERIALS

Mohs Scale	Samples	Knoop Numbers
2	Gypsum	32
3	Calcite	135
4	Flurite	163
5	Apatite parallel to axis	360
5	Apatite perpendicular to axis	430
6	Albite	490
6	Orthoclase	560
7	Crystalline quartz parallel to axis	710
	Crystallize quartz perpendicular to axis	790
8	Topaz	1250
	Carboloy	1050 to 1500
	Regular alundum No. 1	1635
9	Regular alundum No. 2	1625
	Regular alundum No. 3	1620
	98-alundum No. 1	1670
	98-alundum No. 2	1680
10	Black silicon carbide No. 1	2150
10	Black silicon carbide No. 2	2050
10	Green silicon carbide No. 1	2130
10	Green silicon carbide No. 2	2140
11	Molded boron carbide No. 1	2250
11	Molded boron carbide No. 2	2260
11	Molded boron carbide No. 3	2250
12	Diamond	5500–6950

Knoop hardness numbers of Mohs Minerals and some abrasive materials were also given. Inasmuch as these results differ somewhat from those given originally (S. Scholes, *Handbook of the Glass Industry*) and include other materials, this data is given in Table II.



Data, Courtesy of Harbison-Walker Refractories Company, Pittsburgh, Pa.

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GLASS DIVISION MEETS AT BEDFORD SPRINGS . . .

(*Continued from page 646*)

chines used in the assembly of incandescent lamps (Operations such as flare making, stem making, sealing-in, cullet cut-off and tipping) are considered from the following viewpoints: 1) The burner itself: designed for the gas used and the operation to be performed; 2) The burner mounting: manifolds and valves used; 3) The mixer, i.e., the means of supplying the proper quantity of air or oxygen to properly burn the gas and supply the proper gas-oxygen or air mixture pressure to the burner head.

In the case of the burner, the four most important characteristics for efficient operation are: 1) Flame shape must be such as to concentrate the heat just where it is wanted; 2) Flame temperature must be right for the job; 3) Flame character must be under control, i.e., oxidizing for lead glass, reducing for alumina glass; 4) Heat release must be proper for the job. The heat release must be sufficient to bring the glass to the working viscosity in the machine index time. The general classes of burners (piloted) are: 1) Single hole, long focus; 2) Multiport, short focus; 3) High pilot ratio screen, short and long focus, single and multiport; 4) Piloted oxygen burners.

Low velocity flames (pilots) are used around the main jet for the prime purpose of keeping the flame anchored to the burner head, i.e., to reduce blow off or lifting of the flame. In the discussion on the effect of pilots on flame retention, data was given which showed that the slow burning natural gas when compared with hydrogen and manufactured gas required much more gas in the pilot and a much larger burning area for this gaseous mixture. Piloted ports give a greater heat release than unpiloted ports, the exact ratio increase being affected by burner construction. The flame length focus and form (factors which determine where the working temperature of the flame is) are all functions of the ratio of pilot to jet area and the pilot burning area. Some of the factors operating to change flame shape and focal length are: 1) Gas used. Hydrogen or carbon monoxide gases give a short, sharp cone and high temperature spot, the temperature of the rest of the flame falling off rapidly. A natural gas cone is 50 per cent longer than manufactured gas and the temperature of the flame falls off more slowly. 2) Pilotage. The greater the pilotage and pilot area, the fatter the flame and the tendency to be of more even temperature for a longer distance. 3) Output rate of burner (BTU per in.^{2} of port per hr.). This is the characteristic which determines the actual focal length when burning on any given gas, but the output rate is a function of the gas, the pilotage and the burner head pressure.

The size of the jet (including pilot), the flame speed of the burning mixture and the burner head pressure, govern the quantity of gaseous mixture released by a burner (Heat release, BTU capacity per hour).

Many troubles laid to faulty burner design are the fault of the burner mounting, the manifolds too constricted, too many turns and too small. It is suggested that it is wise to err on the large size of all these factors.

In all lamp working, the two pipe system is used to mix the gas and air or oxygen gas at 18" W.C. and air at 4PSI are the usual supply to a venturi type mixer. Both gas and air are under close pressure control. The venturi type mixers in use today are two general types: 1) A.G.F. and 2) Adjustable Tee. These mixers serve a dual purpose: a) mix gas and air or oxygen in desired proportions and b) make the burner head pressure.

In comparing various gases, it has been found that the product of the net BTU per ft. of gaseous mixture, times the speed of flame propagation, is a measure of the ability of a flame to transfer heat to an object (Specific Flame Capacity). The following highest specific flame intensities (BTU-in^2-sec.) were given: hydrogen, 6.37; city gas, 1.46; coal gas, 1.35; and methane, 0.69. This data indicates why it is easier to do glass working with manufactured gas than with natural gas.

The effect of inerts on heat release of a burner was discussed from the theoretical side and the advantage of the use of oxygen instead of air was shown. In actual practice, the large theoretical advantage ratios are seldom obtained due to factors of burner manufacture not under control, but their potentiality is there to spur on burner development. An important point to be noted is the change in the relative positions of natural and manufactured gas when burned with air or oxygen. For example, natural gas when burned with air has 60 per cent of the heat release of manufactured gas burned with air, but has 128 per cent of the heat release of manufactured gas when both are burned with oxygen.

STATISTICS OF THE RUSSIAN GLASS INDUSTRY

The production of glass in U.S.S.R. in 1947 exceeded that for 1946 by 30.2%. For the 3 main types of glass, the increases were: window glass 24%; laminated glass 19%; and ground glass 58%. The absolute values are not revealed.

Much attention was paid in 1947 to raising the rate of withdrawal of Fourcault glass. This rate (in meters per hour and feet per hour) was on the average,

		m./hr.	feet/hr.
First quarter	1947	51.6	169.2
Second quarter	1947	52.0	170.6
Third quarter	1947	54.1	177.4
Fourth quarter	1947	58.5	191.9

The average rate for 1947 was 54 m./hr., an improvement over 51 m./hr. in 1946. It was planned to reach the rate of 60 m./hr. in 1947, and it was planned to exceed the rate of 80 m./hr. in 1948.

AMERICAN WINDOW GLASS COMPANY AND FEDERAL TRADE COMMISSION AGREE ON ADVERTISING "LUSTRAGLASS"

The American Window Glass Company has settled, by stipulation with the Federal Trade Commission, certain complaints which the Federal Trade Commission had received concerning American's advertising of its sheet glass which it sells under the trade-mark "Lustraglass."

While believing that the charges filed with the Federal Trade Commission were unfounded, the company nevertheless agreed to avoid statements in future advertising which the Commission or others might possibly find objectionable. It accordingly stipulated that in its future advertising, it would not represent that "Lustraglass" is as free from distortion as plate glass, that window glass other than "Lustraglass" is generally characterized by discernible distortion and finally that, when American represents that sunlight transmitted by "Lustraglass" has therapeutic benefits, it will also state that direct exposure to the transmitted rays is necessary and further state the approximate percentage of the total ultra-violet rays in sunlight which are transmitted by "Lustraglass."

For several years the American Window Glass Company has advertised "Lustraglass" as the "Ultra-Violet Ray Window Glass". Although this slogan was also complained of, the Federal Trade Commission agreed that such advertising was proper because it was found that "Lustraglass" does transmit a substantial amount of the ultra-violet rays present in sunlight.

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INVENTIONS AND INVENTORS . . .

(*Continued from page* 635)

invention in which a bending furnace 5 contains a bending mold 6 for supporting a sheet 7. Mounted above the sheet is a shield 8 which retards the heating of the central portion of the sheet. The furnace is heated by burners 13 and the heat is directed upwardly by baffles 15 and 16 into the heating chamber 17 over the sheet to be bent.

The bending mold 6 may be formed of sand and shaped as desired but as here shown it has a flat central portion 18 and inclined ends 19 and 20. The sheet 7 overhangs the inclined ends so that when heated, the ends of the sheet drop onto the mold as shown at 7b. The shield 8 retards the heating of the central part of the sheet while allowing the end portions to become softened. The ends of the shield overhanging the inclined portions of the mold may be provided with V-shaped teeth 24 and 23 so as to gradually increase the heat toward the edges. The shield is supported on spaced rods 24 which rest on piers 28 and 29.

By this construction the main portion 21 of the shield keeps the flat central portion of the sheet from direct radiation while permitting a gradually increasing heat at the edges to be bent. Several modifications of the invention are shown in the patent.

The following references are of record in the file of this patent: United States Patents: 760,959, Connington, May 24, 1904; 1,582,374, Berglund, Apr. 27, 1926; 1,999,721, Dimmick, Apr. 30, 1935; 2,215,228, Oliver, Sept. 17, 1940; 2,218,254, Wengel, Oct. 15, 1940; 2,235,352, Bates, Mar. 18, 1941; and 2,348,278, Boylet et al., May 9, 1944. Foreign Patents: 3,093, Great Britain, Aug. 14, 1877; 8,208, Great Britain, May 26, 1884; and 351,862, Great Britain, July 2, 1931.

EMPLOYEES GLASS EXHIBIT

Knox Glass Company, Palestine, Tex., employees took over an entire corner of an Anderson County Fair building for their glass exhibit.

The exhibit is another phase in a "Buy in Glass" campaign launched by three locals of the Glass Bottle Blowers of America this summer. Samples of more than 300 Knox-produced glass containers were arranged on display shelves and a revolving tiered platform, all decorated in red and white colors.

The glass workers campaign is dependent upon general health of industry and seeks to sell glass to the general public. It has been studied by other glass workers for possible adoption throughout the Southwest.

BATTELLE TO CONSTRUCT NEW LABORATORY

To house additional laboratories required for its expanding research, Battelle Institute will begin construction of a new half-million-dollar laboratory building late this year. The building is scheduled for completion in 1949.

According to Director Clyde Williams, the three-story structure will contain space for 103 unit laboratories, plus large open areas for pilot-plant operations. It will contain approximately 80,000 square feet of space.

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BORIC OXIDE—ITS CHEMISTRY AND ROLE IN GLASS TECHNOLOGY . . .

(*Continued from page* 632)

Color Indicator, (Cr^{3+}-Cr^{6+}), Ztschr. anorgan. allgem. Chemie, *250*, 159-172 (1942).

Lyon, K. C., Calculation of Surface Tensions of Glasses, Journ. Amer. Ceram. Soc., *27*, 186 (1944).

Majumdar, S. K., Banerjee, B. K. and Banerjee, K., X-ray Studies of Sodium Borate Glasses Containing Sodium Chloride, Nature *156*, 423 (1945).

Majumdar, S. K. and Palit, R. M., X-ray Analysis of NaCl Dissolved in B_2O_3 Glass, Journ. Indian Chem. Soc., *19*, 461-466 (1942).

Markin, B. I., Electric Conductivity of Silver Borate Glasses, Russ. J. General Chem., *11*, 285-292 (1941).

Markin, B. I., Electric Conductivity of Three Component Alkali Borate Glasses, J. techn. Phys., *10*, 66 (1940).

Maselew, L. J., X-ray Transmitting Glasses (B_2O_3-BeO-Li_2O), Russ. Journ. Applied Chemistry *13*, 1288-1302 (1940).

Mazzetti, C. and De Carli, F., Anhydrous Borates of Lithia, Cadmium, Lead and Manganese, Gazzetta Chim. Ital., *56*, 19-28 (1926).

McCulloch, L., A Crystalline Boric Oxide, Journ. Amer. Chem. Soc., *59*, 2650-2652 (1937).

McMurdie, H. F. and Bunting, E. N., X-ray Studies of Compounds in the System PbO-SiO_2, J. Res. Nat. Bur. Standards *23*, 543-547 (1939).

Menzel, H. and Slivinski, S., Studies in the System Li_2O-BeO-B_2O_3, Z. anorgan. allgem. Chem., *249*, 357-385 (1942), The Glass Industry Aug. 1945 *26*, No. 8 375.

Morey, G. W., Annealing of Pyrex Chemical Resistant Glass. With an X-ray Study by B. E. Warren. Ind. and Eng. Chemistry *27*, 966-971 (1935).

Morey, G. W., The Devitrification of 'Pyrex" Glasses, J. Amer. Ceram. Soc., *14*, 529-531 (1931), The "Pyrex" glass 774 has the lowest liquidus temperature of any known mixture of so high a silica content.

Morey, G. W., The Effect of Boric Oxide on the Devitrification of the Soda-Lime-Silica Glasses, The System Na_2O-CaO-B_2O_3-SiO_2, J. Amer. Ceram. Soc., *15*, 457-475 (1932).

Morey, G. W. and Ingerson, Earl, The Melting of Danburite, J. Mineralogical Soc. Am. *21*, 194 (1936).

Morey, G. W. and Merwin, H. E., Phase Equilibrium Relationships in the Binary System Sodium Oxide-Boric Oxide With Some Measurements of the Optical Properties of the Glasses, J. Amer. Chem. Soc., *58*, 2248-2254 (1936).

Muhlig, J. M., The Composition of Fourcault Glass, Glastechn. Ber., *12*, 45-50 (1934).

Muller, R. L. and Markin, B. I., Electric Conductivity of Alkali and Alkaline Earth Borates, J. Phys. Chem., *5*, 1262 (1934), *7*, 595 (1936).

Muller, R. L. and Weinstein, C. V., Investigation of the Velocity of Solution of Alkali Borate Glasses, Acta Physicochimica U. S. R. R. III, 465 (1935).

Nordberg, Martin E., Properties of Some Vycor Brand Glasses, J. Amer. Ceramic Soc., *27*, 299-305 (1944).

Owens-Illinois Glass Co., Effect of Boric Oxide on Properties of Soda-Dolomitic Lime-Silica Glass, J. Am. Ceram. Soc., *31*, 8-14 (1948).

Parmelee, C. W. and Badger, A. E., Effects of Borax and Alumina in Glass, Glass Ind., *15*, 235-238 (1934).

Pavlish, A. E. and Mockrin, I., Development of Hard Glasses, Journ. Amer. Ceram. Soc., *30*, 54 (1947). Melting studies in the pseudo-ternary system Al_2O_3-SiO_2—(CaO + B_2O_3) for developing hard glasses.

Ponomareff, J. F., Investigation of the Glassy State By the Method of Enforced Crystallization, Z. anorgan. allgem. Chem., *89*, 383 (1924).

Potts, J. C., Melting Rate of Soda-Lime-Silica Glasses as Influenced by Composition and the Effect of Minor Constituents, J. Amer. Ceram. Soc., *24*, 43-50 (1941).

Rollet, A. P., On The Borates of Potassium, Compt. Rend., *200*, 1763-65 (1935).

Samsoen, O. and Mondain, P., On the Anomalous Specific Heats of Vitreous Boric Oxide, Compt. Rend., *182*, No. 16 (1926).

Saunders, James B., Expansivity of a Vycory Brand Glass, J. Res. Nat. Bur. Standards *28*, 51-55 (1942).

Southhard, J. C., Thermal Properties of Crystalline and Glassy Boron Trioxide, J. Amer. Chem. Soc., *63*, 3147-3150 (1941).

Spraght, M. E. and Clark, J. D., The Electrical Conductivity of Boron Trioxide-Sodium Borate Glasses, J. Phys. Chem., *38*, 833-838 (1934).

Spraght, M. E. and Parks, G. S., The Coefficient of Thermal Expansion of Boron Trioxide, J. Phys. Chem., *38*, 103-110 (1934).

Schleede, A. and Wellmann, M., X-ray Transmitting Glass, Ger. Pat. 537, 633, Ztschr. f. Kryst. A. *83*, 148 (1932).

Schmidt, R., New Developments of Special Glasses Used in Illumination, Glastechn. Ber., *15*, 89-99 (1937).

Schott, O., Roentgen Ray Transmitting Glass and Sealing of Platinum Wires Into Same, Dtsch. Mechaniker Ztg. 111 (1899).

Schtschukarew, S. A. and Muller, R. L., On the Electrical Conductivity of B_2O_3—Na_2O Glasses, Ztschr. f. phys. Chem., *150*, A 439-475 (1930).

Schurtz, D. D., Some Results Obtained Through the Use of Borax in the Manufacture of Tank Glasses, J. Amer. Ceram. Soc., *13*, 341-344 (1930). Plant experiments carried out at Hocking Glass Co. are described. Addition of borax to the glass gave a better finish and a more desirable ware.

Shartsis, L. and Smock, A. W., Surface Tension of Some Optical Glasses, J. Amer. Ceram. Soc., *30*, 130-136 (1947).

Shartsis, L. Spinner, S. and Smock, A. W., Surface Tension of Compositions in the Systems PbO-B_2O_3 and PbO-SiO_2, J. Amer. Ceram. Soc., *31*, 23-27 (1948).

Von Stackelberg M., Quatram, F. and Dressel, J. (with Spiess, C. E. and Kupffer, M.), Volatility of Boric Acid with Water Vapor. System Boric Oxide-Water, Z. Elektrochem., *43*, 14-28 (1937).

Stalhane, B., On Some Systems of Alkali Borates—Alkali Halides, Ztschr. Elektrochemie *35*, 486-492 (1929), *36*, 404-408 (1930).

Stanworth, J. E. and Turner, W. E. S., Possibility of Preparing Glasses Containing P_2O_5, Al_2O_3, B_2O_3 and SiO_2, Journ. Soc. Glass Techn., *21*, 368-382 (1937).

Swift, H. R., Factors Influencing Fluxing Action of Various Oxides in Low Temperature Borosilicate Glasses, J. Amer. Ceram. Soc., *28*, No. 2, 33-36 (1945).

Tammann, G. and Bandel, C., Thermal Expansion of B_2O_3, As_2O_3, HPO_3 and a Lead Glass and Their Volumes As Functions of Pressure, Ztschr. anorgan. allgem. Chem., *192*, 129-144 (1930).

Tammann, G. and Jenkel, E., Increase of Density of Glasses Solidified Under High Pressure. Return to Normal Densities On Heating. Ztschr. anorgan. allgem. Chem., *184*, 416-420 (1929).

Thomas, S. B., The Conductivities and Dielectric Constants of Glucose and Boric Oxide Glasses, J. Phys. Chem., *35*, 2103-2111 (1931).

Toropov, N. A. and Konovalov, P. F., Binary System MgO—B_2O_3, Russ. Journ. Phys. Chem., *14*, 1103-1109 (1940).

Turner, W. E. S., The Use of Boric Oxide in Glass Making, J. Amer. Ceram. Soc., *7*, 313-317 (1924).

Turner, W. E. S. and Winks, Fr., The Influence of Boric Oxide on the Properties of Chemical and Heat Resisting Glass. I., J. Soc. Glass Techn., *9*, 389-405 (1925). II. Resistance to Chemical Reagents, J. Soc. Glass Techn., *10*, 102-113 (1926).

Volarovich, M., An Investigation of the Thermal Expansion in the Molten State of the Binary System, $Na_2B_4O_7$—B_2O_3, Bull. Acad. Sciences, U. S. S. R., 663-674 (1933).

Volarovitsch, M. N. and Talsti, D. M., Viscosity of the Binary System $Na_2B_4O_7$—B_2O_3 in the Fused State, Bull. Acad. Sci., U. S. S. R., 897 (1930).

Walker, G. E., The Influence of Boric Oxide on the Crystallization of a Soda-Potash-Lime-Silica Glass. Journ. Soc. Glass Techn., *29*, 38-47 (1945). Substitution of boric oxide for silica in a series of glasses caused a reduction in the liquidus temperature and of the rate of crystal growth. In agreement with G. W. Morey the primary phase changed from tridymite to devitrite.

Wang, T. H. and Turner, W. E. S., The Influence of Boric Oxide On The Refractive Index and Dispersion Of Soda-Boric Oxide Silica Glasses, J. Soc. Glass Techn., *29*, No. 136, 390-396 (1945).

Wargin, W. W., Volatility of B_2O_3 From Glass, Optico-Mechan. Prom. *6*, 14-16 (1936).

Warren, B. E., Summary Of Work On Atomic Arrangement In Glass, J. Amer. Ceram. Soc., *24*, 256-261 (1941).

Warren, B. E., Krutter, H. and Morningstar, O., Fourier Analysis of X-ray Patterns of Vitreous SiO_2 and B_2O_3, J. Amer. Ceram. Soc. *19*, 202 (1936).

Warren, B. E., Krutter, H. and Morningstar, O., Fourier Analysis of X-ray Patterns of Vitreous B_2O_3 and SiO_2, J. Amer. Ceram. Soc., *19*, 202-206 (1936).

Weinig, R. and Zschimmer, E., Thermal Expansion of Sodium Borosilicate Glasses Between 25° and 150° as a Function of Their Chemical Composition, Sprechsaal., *62*, 855-857, 874-878, 889-891 (1929).

Winkelmann, A. and Straubel, R., Properties of X-ray Transmitting Glasses, Ann. d. Physik, *59*, 324 (1896).

Winter, A., Transformation Region of Glass, J. Amer. Ceram. Soc., *26*, 189-200, 277-289 (1943).

Zachariasen, W. H., The Crystal Lattice of Boric Acid H_3BO_3, Z. Kristallogr., *88*, 150-161 (1934).

Ziegler, W. and Wellmann, M., U. V. Transmitting Alkali-Beryllium Borate Glasses, Z. techn. Physik, *14*, 288-289 (1933).

Zschacke, F. H., Relative Melting Speed of Glass Batches Containing Hydrated and Anhydrous Borax, Glastechn. Ber., *16*, 13-19 (1938).

Zschacke, F. H. and Vartanian, J., The Relative Melting Speed of Glass Batches Containing Boric Acid and Borax Glastechn. Ber. *13*, 155-163 (1935).

Zschimmer, E., On the Physical Properties of Glasses as Functions of Their Chemical Compositions, Ztschr. Elektrochem., *11*, 629-638 (1905). The refractive indices of potassium silicate glasses goes through a maximum, if B_2O_3 is added.

SYLVANIA ELECTRIC ANNOUNCES NEW SLIMLINE FLUORESCENT FIXTURE

A new, slimline fluorescent lighting fixture, designed for commercial use, has been introduced by Sylvania Electric Products, Inc.

The new fixture, the CSL-496, is an unshielded unit utilizing four T8 fluorescent lamps having a total power of 204 watts. It can be installed either surface or pendant mounted, individually or in continuous rows, but is especially applicable for surface mounting in general merchandising areas.

RESEARCH INVESTIGATION REPORT AVAILABLE THROUGH DEPARTMENT OF COMMERCE

Spectrographic analysis of ceramic materials is the subject of a research investigation for which a series of progress reports are now available, it has been announced by the Office of Technical Services, Department of Commerce.

The reports were prepared by the Applied Research Laboratories under contract to the Signal Corps. They suggest methods for simplifying the analysis of ceramic materials by using spectrographic techniques instead of conventional quantitative methods. One of the purposes of the study was to introduce quantitative control over the raw materials employed in the manufacture of high dielectric constant titanate bodies. Tests were made of alkaline earth titanates and zirconates; stannates, titanium dioxide, zirconium oxide, barium and strontium carbonates, eyerite, kaolin and boric acid.

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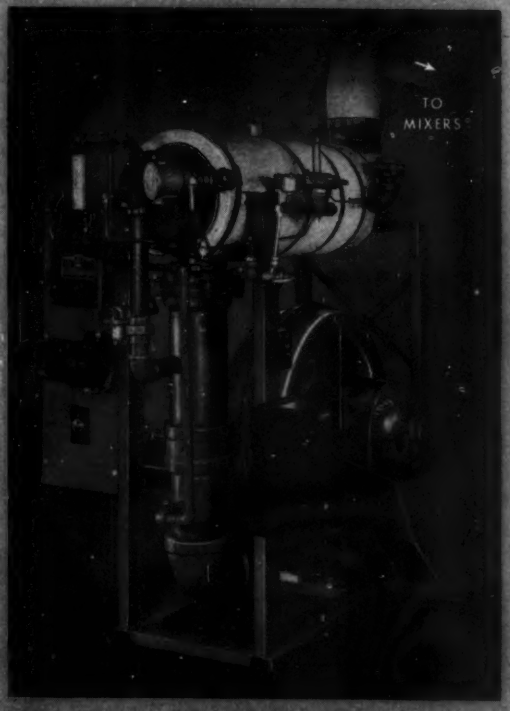


Fig. 1 – Air Heater.

AVOID CRITICAL GAS SHORTAGES

Many industrial ovens, furnaces and boilers are fired with gas burners which do not lend themselves to the substitution of direct oil burners during the trying days of gas curtailments. For such applications North American offers the Oiltogas Converter.

Fig. 2 – Insert Assembly and Mixer.

PRODUCES CLEAN CARBON-FREE GAS FIRES

The principle of the Oiltogas Converter is to supply air at 700°F. to standard North American Aspirator (Gas-Air) Mixers. Into the mixer (through the displacement rod) is injected atomized oil. The hot air immediately vaporizes all of the finely atomized oil and carries the gaseous fuel thus generated to any number of burners.

The air heater shown in Figure 1 is direct oil-fired and is entirely automatic in operation and includes flame safety devices. The amount of fire at the furnace or oven burners is controlled by valves in the hot air line leading to the mixers.

Because of the high air temperatures used and the excellent atomization of the fuel, it is found that even on #3 catalytic fuel oil no carbon or condensate is formed in the piping or burner manifolds. This eliminates the necessity for installing condensate return piping and for periodic cleaning.

*A combination of Standard Combustion Equipment, backed by 30 years of Dependable Service

[redacted]

GLASS MELTING . . .

(*Continued from page* 620)

are possible. Functionally, it permits continuous firing from both sides of the tank and the concentration of the heat on the glass instead of the sidewall and crown. It helps to strengthen lateral convection currents and maintain their uniformity. As the difference in viscosity is less the detrimental effect of longitudinal convection currents can be reduced. There still will be little mixing except for the slight diffusion, and no penetration of adjoining currents but these longitudinal currents can be more easily turned, and thereby reduce the length of their travel and their consequent detrimental effects.

It will reduce the time, area and fuel now required in the refining stage. Structurally, elimination of regenerators and bridgewall enables the tank designer to create a simpler and cheaper construction. Structurally, the present regenerators compel the engineer to employ poor construction. The port openings have to be designed as stacks rather than burner intakes whose construction and operation normally differ widely. Refractory deterioration and radiation are greatly increased. Wide short tanks are necessary for fuel combustion reasons, whereas the control of convection currents especially the turning and shortening of the harmful longitudinal currents call for a relatively long narrow tank. Observation of tank interior is difficult (well nigh impossible) owing to excessive heat from radiation, and the limited space available owing to port enclosures and regenerator stacks. Any manipulation to the glass bath is impossible now, but with unobstructed side walls many tools can be employed when such manipulation is desired. Relatively unbroken side walls above the glass level and the narrowed crown could be safely and efficiently insulated and tank radiation reduced.

This is not a technical description of any particular structure, and the suggestions of certain types of structure are employed here merely to clarify the functional principles of operation.

Part IV. What to do about it.

There is a large amount of information available consisting of inventions, trials on both experimental and commercial scale. All references above have been publicly disclosed. There is much other data that is confidential but could doubtless be available to interested parties. There is one case where a process based on this general theory is employed to a certain extent on a large commercial scale with beneficial results. These numerous patents, trials and commercial operations should receive careful scrutiny to separate the chaff from the wheat.

The patent situation is one where expired patents or those nearly expired have suggested practically all the above references and innumerable other structures and ideas. The author does not believe that any patent course is possible whereby royalties would be adequate to repay the expense of trials and experiment necessary to successfully complete the system proposed herein commercially.

Some research, some invention, much more engineering and particularly a considerable use on an actual commercial basis will be needed. That eliminates organizations dependent on patent royalties, contracting builders, combination, contracting, and engineering organizations, etc. which have up to date been responsible largely for whatever progress there has been made.

The tonnage of glass melted in this country has increased on the order of ten times that of only a few years back. There are individual companies whose tonnage is now many times that of the whole industry only a few years ago. Trials on a commercial scale appear to be practical only to companies who have large tonnage, and who could make commercial use of the glass produced in the long trial periods necessary. There are many such organizations and it would appear practical to combine efforts. The know-how, and other advantages should be sufficient compensation for successful efforts. Large corporations, with some exceptions, tend to place less reliance on patents as a major basis for their differentials.

Many, notably the automobile companies, do not even attempt to commercialize them and their main interest is to avoid law suits from outsiders. If an interest in this subject matter should develop, it is the author's opinion that some satisfactory arrangement can be worked out whereby an adequate study of the possibilities, at least, could be carried out. If, as a result of such study, the potential results should appear to warrant the risks involved, some arrangement could be made to develop a successful commercial process with profit to both owner and the public.

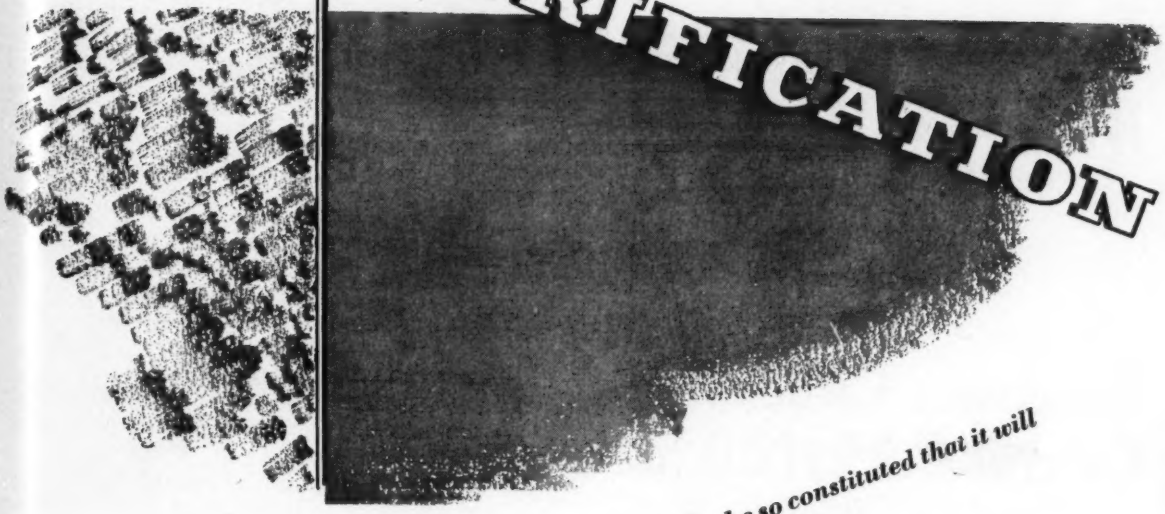
A successful outcome can not be achieved on any basis similar to that of past years where uncoordinated efforts, fantastic inventions, insufficient financial resources, poorly built and operated experimental units, and many other factors that are "surefire" roads to failure have been the rule rather than the exception. Much can be learned by a careful study of past efforts. Not the facts of success or failures, but the causes which contributed to results (either bad or good) should furnish information of much value.

If I may be excused for a personal reference, an incident occurred when I first began to develop the plunger feeder which bears my name that is pertinent to this presentation. With a friend I was watching an Owens Bottle Machine in operation. My friend was astonished and asked me why I thought I could conceive anything that could possibly compete with this, to him, the last word in perfection in bottle making. My reply was that I had read about the "Dinosaurs" and even seen their skeletons; that any such enormous moving machine that had to plunge into a bath of molten glass to pick up an ounce or two, then back out and again plunge its many tons for another ounce looked to me too much like a Dinosaur feeding.

The gob feeder which I felt was more on the evolutionary beam, moved the two ounces into the monster which could be relatively stationary and inexpensive. The present tank furnace is just such a "Dinosaur" and ignores many of the basic evolutionary laws. It will ultimately fail or at least shrink, whenever a valid attempt is made to eliminate its diseases by removing their causes instead of treating them with palliatives as is now done. If only a fraction of the time and money now spent merely to study their ills would be used to develop a furnace built on a sound fundamental basis,

(*Continued on page* 658)

DE VITRIFICATION



● *The composition of a glass must be so constituted that it will remain in a liquidus condition throughout the working and forming operations. B_2O_3 as a minor constituent is helpful in maintaining this condition.*

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GLASS MELTING . . . .

(*Continued from page* 656)

most of these ills would automatically die with the removal of their cause. Besides reduction of cost, such a furnace would do what the present one does not, never has and never can; viz., produce good glass continuously and controllably.

SURFACE ATTACK AND FLAKE FORMATION IN CONTAINERS . . .

(*Continued from page* 628)

of autoclave treatment and prolongated storage at ambient temperature would have to be studied for each type of glass. It may even depend upon the shape and capacity of the ampuls. At any rate, glasses forming flakes must be considered doubtful.

d) The flakes come from the fragmentation of a very fragile skin forming at the interface glass-water (not vapor) which is detached by the most minute motion and breaks upon cooling.

e) The practical determination of the value of a glass, or rather an ampul, or a container of any kind, from the viewpoint of disintegregation of its surface into flakes is a question of species.

Each type of glass or ampul must be investigated by a double series of tests:

1) Treatment of containers or ampuls filled with controlled double-distilled water—or the appropriate test liquid—in the autoclave at temperatures higher and for times longer than in actual manufacture. If no flakes appear the conditions must be pushed until they do appear eventually, although it does not seem necessary to go beyond 150-180°C.

2) Prolonged storage at ambient temperature (15-25°C) of ampuls or containers filled with double-distilled water—or the appropriate test liquid—both autoclaved and not autoclaved, and determination of the time of stability until flakes appear. The prudent confrontation of the results of the storage and high temperature tests will reveal to which extent there exists an equivalence.

It will always be desirable to determine the weight of flakes per 100 cc. after filtration through an extremely fine filter or centrifugation and subsequent calcination. The results will be amplified in a useful manner by the establishment of extreme and mean dimensions and their distribution.

REFERENCES

1. A. Thuret, "Critical Examination of Methods of Determination of the Alterations of Glass by Water". Chim. et Ind. *53* (3) 185-197 (1946).
2. J. Volckringer, "Communication to the Permanent Commission of the Codex". (1947).
3. A. L. Hinson, D. C. Smith and J. F. Greene, "Changes in Distilled Water Stored in Glass Ampuls". J. Amer. Cer. Soc. *30* (7) 211-214 (1947).
4. O. Richter, "Significance of Glass in Plant Physiology and Biology. Value and Danger of Glass in Biological Work". Glastech. Ber. *21* (4) and (5) 89-110 (1943).
5. M. Grubler, "Effect of Free Alkali Upon Morphine and Adrenaline". Pharm. Post. *40* 579 (1907); Chem. Centr. Bl. IV 1424 (1907); (see H. Thiene "Glass" Vol. 2 p. 524).
6. A. Mauri, "Some Aspects of Surfaces of Glasses Neutral to Autoclave Treatments". Giornale di Chimica Industriale ed Applicata *7* 452; Centr. Bl. 765 (1926); Glastech. Ber. *3* 465 (1925/6); H. Thiene, "Glass" Vol. 2 p. 524.
7. W. Turner, "Testing of Glass Containers for Chemical Durability". J. Amer. Cer. Soc. *18* (5) 135-441 (1935).
8. F. R. Bacon and O. G. Burch, "Effect of Time and Temperature on Accelerated Chemical Durability Tests Made on Commercial Glass Bottles". J. Amer. Cer. Soc. *23* (5) 147-151 (1940).
9. J. H. Brewer and J. H. F. Dunning, "Glass Particles in Ampuls". The Glass Packer, July 1947 p. 516-517 et 551.

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By order of the United States District Court for the Northern District of Ohio, Western Division, Owens-Illinois Glass Company offers for sale as a unit all real estate, buildings, machinery, production equipment (not including molds), tanks and furnaces (except experimental machinery and furnaces) located at Chicago Heights, Illinois, and which were a part of the assets acquired by Owens-Illinois Glass Company from Kimble Glass Company on July 1, 1946.

In accordance with the order of the Court such property is offered for sale for cash to any purchaser approved by said Court, subject to prior sale, at the fair market value of said property as a glassware manufacturing plant, as determined by an appraisal made by The Lloyd-Thomas Company, which said appraisal has been duly filed with the Clerk of said Court at Toledo, Ohio., where it may be inspected. Additions and improvements made to the property described above since July 1, 1946, and prior to consummation of sale are not included in the appraised value aforesaid but are offered for sale as a part of the unit for an additional consideration equal to the cost thereof to Owens-Illinois Glass Company.

In connection with the sale of the property and additions and improvements thereto above described, Owens-Illinois Glass Company will assign or cause to be assigned to the purchaser thereof for the consideration hereinafter set forth, all its rights in and to the following machinery and equipment leased from Hartford-Empire Company situate on said premises on July 1, 1946, to-wit:

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1—5 head I S machine with same

2—36" x 74' lehrs, gas fired with top vertical discharge, motor driven steel plate exhaust fan, and all regular equipment

The consideration to be paid by the purchaser to Owens-Illinois Glass Company for the assignment of its rights in the leased machinery aforesaid shall be cash in such an amount as will reimburse Owens-Illinois Glass Company for a fair proportion of any and all payments made in connection with said leased machinery by Kimble Glass Company or Owens-Illinois Glass Company which may be considered as costs of installation, advance payments for minimum annual royalties, license fees, parts, insurance and taxes.

In the event of such sale, possession will be delivered not later than six months after the consummation of such sale to a purchaser approved by the said Court.

Address all inquiries to

Owens-Illinois Glass Company
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INTERFACIAL MICROREACTIONS IN GLASS MELTS . . .

(*Continued from page* 631)

gives access to a mechanism which has not been completely understood by the engineer and the physical chemist. The details of the melting process have not been subject to sufficient analysis and the prevailing simple concepts require supplementary revision.

The present study attempts to explain melting phenomena on the basis of physical concepts. The essential role of molecular forces has been substantiated in agreement with earlier microscopic work. It may be expected that further details will be explained in a satisfactory manner by investigations of this kind.

REFERENCES

1. "The Schlieren Method and Its Applications." Ergebnisse der exakten Naturwissenschaften, Bd. XX, (1942), S. 303-439, 125 Abb.
2. Glastechn. Ber. Bd. 21, (1943), Nr. 3, S. 75.
3. H. Jebsen-Marwedel: "Remarks on the Influence of Surface Tension in Glass Melting Processes." J. Soc. Glass Technol. 2, (1937), S. 436-441.
4. H. Jebsen-Marwedel: "Interfacial Forces as the Principle of the Liquidation of Cords in Liquid Glasses." Glastechn. Ber. Bd. 21, (1943), Nr. 3, S. 57.
5. M. A. Knight: "Surface Tension and Persistence of Cords in Glass." Journ. Am. Cer. Soc. Vol. 27, No. 5, May 1944.
6. Andre Marcelin: "Surface Solution," ed. Wo. Ostwald, publ. Steinkopff, Dresden 1933.
7. H. Jebsen-Marwedel: "Qualitative Mechanics of Solution." Angewandte Chemie 1947.
8. H. Jebsen-Marwedel: "Influence of Surface Tension on Glass in Fusion." Bulletin de l'Institut du Verre, Vol. I (1946), Nr. 5.
9. W. Weyl, Bulletin de l'Institut du Verre, Vol. I (1946), Nr. 3, S. 1.

F. R. MATSON JOINS PENNSYLVANIA STATE COLLEGE

Frederick R. Matson has joined the Division of Ceramics of The Pennsylvania State College as Professor of Ceramics. He was formerly associated with Armstrong Cork Company where he had been head of the Glass Research section of the Research Laboratories for four years. Prior to that he had been at the National Bureau of Standards in the Glass Section for two and one half years working on development projects relating to the manufacture of optical glass.

In his new position, Dr. Matson will teach undergraduate and graduate courses in ceramic petrography, silicate chemistry and ceramic raw materials. In addition to supervising research in various fields of modern ceramics, he is planning to engage in the use of recently-developed research techniques to trace the technical development of early ceramic wares.

FIBERGLAS CORPORATION ESTABLISHES PACIFIC COAST DIVISION

The establishment of a Pacific Coast Division of Owens-Corning Fiberglas Corporation and the appointment of L. R. Kessler as its General Manager have been announced by Harold Boeschenstein, President.

The creation of the separate division is designed to handle construction, manufacturing and sales operations of the company in the Pacific Coast area and neighboring western states.

Construction of a new Fiberglas plant at Santa Clara, California, is now well under way and production is scheduled to start there in July 1949.

FIRE FINISHING OF BOTTLES WITH OXY-FUEL GAS FLAMES . . .

(*Continued from page* 623)

lators to accurately control pressure, a device for thorough mixing of the gases and a compact burner unit designed to assure the control necessary for optimum operation of the process.

The correct flow of gases to the burner is controlled by a fuel gas regulator and an oxygen regulator to which fuel gases and oxygen are supplied by means of suitable rubber hose or piping. In order to do just the job required, the gases pass to Linde's Oxweld W-44 machine heating blowpipe. This blowpipe is a device which provides for thorough and intimate mixing of the two gases without danger of flashbacks.

The mixed gases then flow through a flexible metal hose to a rotary seal, and finally to the Oxweld fire finishing burners. A uniform flame is provided by the burner, necessary for the even heating of the bottle crown. Burners are compact, occupying a minimum amount of space. Of great importance is the fact that fire finishing heads can be fitted into bottle making machinery without any major changes of equipment.

The heads require very little maintenance other than periodic cleaning. At least once every 24 hours is recommended. This is accomplished through use of cleaning compounds. It is advisable to keep a spare set of heads on hand to allow cleaning of the operating heads without affecting the output of the machine.

Oxygen and fuel gas supplies for this fire finishing process present no problems. Oxygen is normally supplied from manifolded cylinders at pressures up to 80 pounds per square inch. This supply is adequate for most installations. In order to serve the oxygen consumptions of large magnitude more efficiently, the compressed gas cylinder is often supplanted by transporting oxygen in liquid form in tank truck or railroad tank car. The liquid oxygen may then be gasified and pumped by the truck's apparatus into the customer's storage facilities by Linde's Cascade oxygen system, or discharged as liquid into a convertor which automatically furnishes gaseous oxygen to the customer's distribution piping system.

Fuel gases commonly used are natural gas, propane and city gas. Pressures of the order of 10 to 20 pounds per square inch are preferred. Fire finishing equipment has been designed to operate with any of these gases without modification. The only parts which must be changed are the injector in the blowpipe and the spud in the flowmeter. Spuds of varying size are available which can be used with any of these gases.

Oxygen and fuel gas consumptions are affected by such factors as the type of fuel gas, the type of mold, whether double or single cavity, the speed of the machine and the weight of bottles being made.

The bottle maker is provided a means of perfecting his product without extensive changes in his equipment, and without addition of a time-consuming operation.

• Laclede-Christy Company has announced that sales for the nine months ended September 30, 1948, amounted to $7,004,831. This compared with $6,482,257 in the corresponding period of last year.

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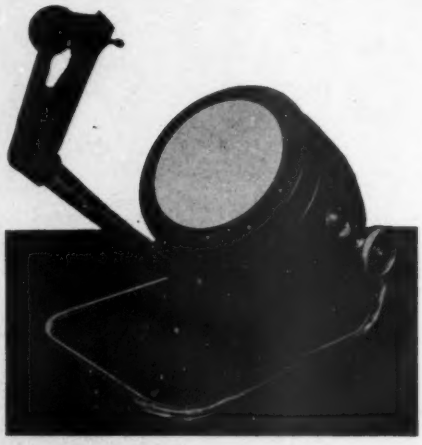

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A.C.S. GLASS GLOSSARY REPRINTS

Reprints of the Glass Glossary which appeared in the September issue of The American Ceramic Society Bulletin have been prepared by The American Ceramic Society. Copies may be obtained at 50 cents each from the Society offices, 2525 North High Street, Columbus 2, Ohio.

This glossary includes several hundred terms in current use among the men in the glass industry, defined according to their usage by glass men. Words which have a commonly accepted glass usage which is the same as their dictionary definition have not been included.

The first of a series of glossaries covering each of the major fields of ceramics, the Glass Glossary is the result of three years' work by the Committee on Classification, Nomenclature, and Glossary of the Glass Division of The American Ceramic Society. It will eventually be consolidated with the glossaries from other fields, and published as a Ceramic Glossary.

Members of the Glass Division committee which prepared the Glass Glossary are H. H. Holscher, Chairman, Owens-Illinois Glass Co.; J. E. Duncan, Pittsburgh Plate Glass Co.; C. H. Hahner, National Bureau of Standards, Washington, D. C.; H. R. Lillie, Corning Glass Works; A. K. Lyle, Hartford-Empire Co.; and S. R. Scholes, New York State College of Ceramics, Alfred, N. Y.

● James M. Ashley, Director of Public Relations of the Libbey-Owens-Ford Glass Company, has been elected President of the Producers' Council, Inc. He succeeds David S. Miller of Armstrong Cork Company.

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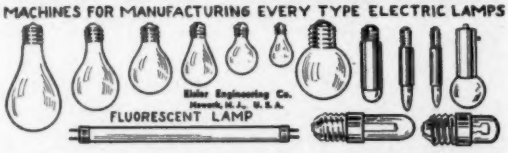

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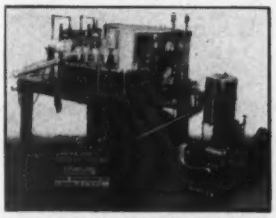

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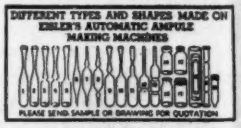
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O. HOMMEL APPOINTMENT

John F. Matejezyk has recently been appointed coordinator of research and manufacturing for The O. Hommel Company, it has been announced.

Mr. Matejezyk came to O. Hommel from the Pittsburgh Coke and Chemical Company where he was head chemist in the Activated Carbon Division supervising research and process control. Prior to that, he had been engaged in organic analytical research related to the development and production of new compounds.

A graduate of Kanty Preparatory School and Duquesne University, Mr. Matejezyk has done post-graduate work in chemistry at the University of Pittsburgh. He was a member of the chemistry faculty at Duquesne University from 1928 to 1941 when he was called to active duty in the Chemical Corps of the U. S. Army. Following his discharge, he was appointed lecturer in chemistry at Duquesne University.

G-E NAMES ENGINEERING MANAGER

The appointment of Dr. Charles E. Reed as Engineering Manager of the Chemical Department has been announced by General Electric Company. Dr. Reed has been Manager of the chemical engineering division of the department.

In his new position, Dr. Reed will have responsibility for new product development, chemical engineering process development, methods and equipment development, facilities engineering and engineering policy for the Chemical Department.

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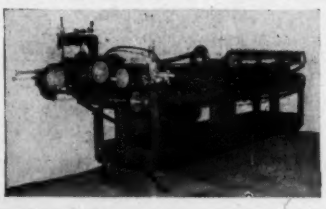

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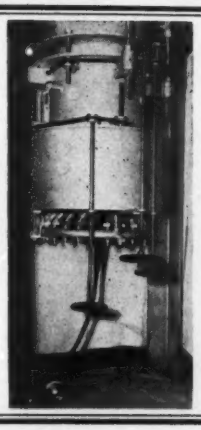

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